PRIORITIZING POLLUTION PREVENTION PROJECTS USING THE DISPLACED IDEAL MODEL FOR THE ALLOCATION OF LIMITED FUNDS

THESIS

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THESIS

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Preface

The purpose of this research was to provide a method to assist decision makers within Air Force Materiel Command (AFMC) in the allocation of limited financial resources. More specifically, a tool was developed to prioritize the large number of pollution prevention projects submitted to AFMC Headquarters for funding. This model incorporates theory from the Displaced Ideal Model (DIM) which is able to meet all of the prerequisites identified by the decision makers. It is referred to as the DIM Alternative Ranking Technique (DART).

This research involved data collection both at AFMC Headquarters and at several subordinate bases. Headquarters decision makers provided information regarding the many criteria they consider when ranking projects for funding. Environmental managers at base level supplied extensive data on several pollution prevention projects which were used to test DART. Analysis and refinement of many of the components of this new technique resulted in a workable tool. DART's greatest potential contribution is not only its ability to assist decision makers in prioritizing projects on a large scale, but its ability to assist in communicating their reasons for making funding decisions to their subordinates.

In conducting this research, we had a great deal of support from others. To Dr. Kashiwagi, we are indebted to you for introducing us to Zeleny's Displaced

Ideal Model. Thank you for your long-distance guidance and support. To Lt Col Kehias and Deborah Peterman, we wish to thank you both for the many times you weighted our criteria, and of course for your full support to include financing our data collection trip. To Allan Rockswald, we thank you for sharing your ingenious idea of using a computerized spreadsheet to prioritize projects. Also, for your gracious hospitality during our visit to McClellan AFB and over our extended telephone conversations. Finally, we would like to offer our sincere thanks to Scott's wife, Nora, for her support throughout the completion of this thesis. Without your support, Nora, this would not have been possible -- not to mention the fact that both authors would have starved to death months ago. In addition, we would like to thank Rick, Debra's husband, for his endurance in waiting out the eighteen months for her to finish this thesis and return home.

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Abstract

This research developed a model to prioritize pollution prevention projects for the distribution of limited financial resources. This model was designed for use at the major command (MAJCOM) level. Each MAJCOM is allowed to select the attributes believed to be most appropriate for evaluating pollution prevention projects. The system also allows the flexibility for MAJCOMs to weight the attributes in accordance with requirements. The model uses "fuzzy logic" and the Displaced Ideal Model (DIM) to prioritize projects which currently do not have an imminent compliance deadline, but are important due to potential noncompliance with future regulations. These projects are also important because their completion demonstrates a commitment to good management practices which make better use of resources and otherwise enhance the environment. The model uses the "amount of information" given by the data to integrate and compare qualitative and quantitative criteria. The prioritization includes considering factors such as total project cost, health and safety considerations, and political sensitivity. The model can also be used to prioritize projects that are currently out of compliance (Level I) or projects which must meet an established deadline before it lapses into noncompliance (Level II).

PRIORITIZING POLLUTION PREVENTION PROJECTS USING THE DISPLACED IDEAL MODEL FOR THE ALLOCATION OF LIMITED FUNDS

I. Introduction

Background

An increase in the level of national environmental awareness has taken place over the last two decades. Several incidents during the 1970s received a great deal of publicity and helped bring environmental issues to the forefront. One event took place between 1976 and 1978 at Love Canal. Hazardous chemicals were disposed of in accordance with laws of that time, but heavy rains caused these chemicals to surface in basements of nearby homes forcing the evacuation of 255 families (40:27). In 1979, a partial core meltdown occurred in a nuclear reactor at Three Mile Island which generated fears about the safety of other nuclear reactors (10:84). These incidents brought an emotional reaction from the public, the general consensus being that people ". . . have a right to clean air, pure water, and to the preservation of . . . the environment," and that "natural resources . . . are the common property of all the

people, including the generation yet to come" (27:16). These events and others raised questions as to the adequacy of existing environmental legislation.

Before the events at Love Canal and Three Mile Island took place, movement toward improving the nation's environmental standing had already begun. The National Environmental Policy Act of 1969 (NEPA) was a cornerstone of environmental legislation which helped steer the country in the direction of this new compliance requirement. NEPA outlined general policy requiring ". . . all agencies of the federal government to integrate environmental concerns into their planning and decision making" (27:140). More specific guidelines became necessary, however, when questions arose regarding the need for federal agencies to comply with state and local laws (34:88). The United States Environmental Protection Agency (EPA) clarified the role of federal agencies with this statement: "Federal agencies generally must comply with all provisions of Federal environmental statutes and regulations as well as all applicable State and local requirements . . ." (26:x). The leader of the largest branch of the federal government, the Secretary of Defense, established a goal for the DOD when he said, "I want the Department of Defense to be the Federal leader in agency environmental compliance and protection" (4:1).

The DOD has since demonstrated its commitment to environmental compliance by increasing funds allocated to correct environmental problems, in spite of a shrinking budget (35:6 Mar 92). For example, the budget for the Defense

Environmental Restoration Program (DERP), an environmental cleanup program, increased from $159 million in 1984 to $1.1 billion in 1991. DERP actions closed out nearly half of the 14,000 toxic waste sites owned by the military (14:26).

Despite these efforts, the cost estimates to achieve compliance continue to exceed financial resources allocated by Congress. As illustrated in Figure 1-1, the Air Force requested $884 million for fiscal year 1992 (FY 92) for its environmental restoration budget, but Congress approved only $439 million resulting in a shortfall of $445 million. For FY 93, the Air Force programmed a need for over $1 billion in environmental needs, but anticipated approval of only 40 percent of that request (22:5 Dec 91). The expectation of severe shortfalls requires leaders and managers to establish priorities.

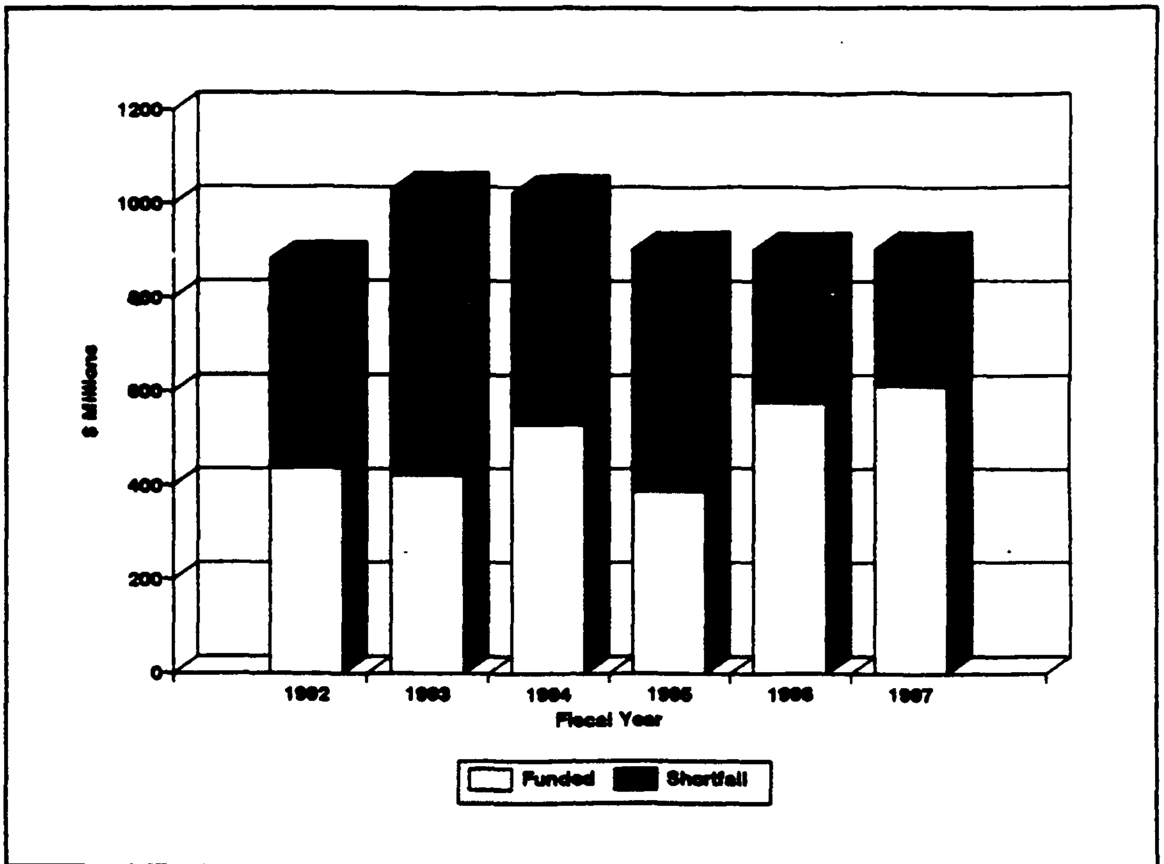


Figure 1-1. USAF Environmental Restoration Budget (22:5 Dec 91)

Within the DOD, the United States Air Force (USAF) established general guidelines and policy to assist in the task of ranking and funding projects, but it is still an inexact process. The existing guidelines place projects into one of four categories: Operations and Services, Level I, Level II, or Level III. Policy directs that projects in the top three categories be funded. Through FY 91, funds were depleted before the fourth category of projects, Level III, could be considered. Prospects for funding Level III projects in FY 92 and FY 93 are much more promising (23:17 Jan 92), but program managers at the major commands (MAJCOMs) will still need to determine which Level III projects to fund. One step in this direction was the creation of a separate account designated for one type of Level III projects -- pollution prevention projects. These projects are now being given increased attention, and additional funding for this new category will be more readily available (1:22 Jan 92). Because additional funding is within reach, it would be wise for Air Force program managers to develop a methodology for ranking pollution prevention projects.

Problem

The purpose of this thesis is to develop a method for USAF MAJCOMs to prioritize pollution prevention projects for the allocation of limited funds.

Objectives

To develop a method for prioritizing pollution prevention projects, the following research objectives were established:

1. Identify the characteristics to consider when evaluating environmental projects.
2. Develop a decision model to prioritize projects based on the characteristics identified.
3. Test and evaluate the decision model by comparing its results with those of present methods of prioritization.

Definitions

Key terms used within this text are defined below:

1. Air Staff or Headquarters United States Air Force (HQ USAF): "In brief, the Air Staff is the military staff for civilian leadership of the Department of the Air Force [e.g., the Secretary, the Under Secretary, and the Assistant Secretaries of the Air Force and the Chief of Staff]" (6:39). Their mission is to organize, train, and support the combat forces. This body develops basic policy and guidance in the performance of their mission (6:39).

2. Delphi Technique: A method of using input from experts to arrive at a decision or consensus (31:123).

3. Dependent Criterion: Criterion whose values are determined by that of one or more other criteria (36:302).

4. Displaced Ideal Model: A model that prioritizes alternative solutions to a problem resulting in a solution closest to the ideal (39:153-156).

5. Environmental Compliance: Conforming to all federal, state, and local environmental legislation as well as Air Force regulations and policies (26:II-1).

6. Environmental Operations and Services (O & S) Projects: Annually-recurring requirements that are required for USAF installations to operate. Examples include permits and fees, hazardous waste management, underground storage tank testing, air and water sampling, Environmental Compliance Assessment and Management Program (ECAMP), spill cleanup and cleanup supplies, Environmental Impact Analysis Process (EIAP) and overhead costs (20:Atch 4).

7. Independent Criterion: Criterion whose values are determined entirely on itself rather than on another criterion (12:70).

8. Installation Restoration Program: "The DOD [Department of Defense] program to identify, investigate and clean up past disposal sites" (5:i).

9. Level I Projects: "Projects and nonrecurring services that address <u>conditions that are out of compliance</u> and are needed to support a signed compliance order, correct deficiencies cited on an inspection (or in a Notice of Violation by a regulatory authority), or get into compliance with a regulatory deadline that has passed" (McCarthy, Atch 4).

10. Level II Projects: "Projects and services that address conditions that must be corrected in order to meet a compliance deadline. In this case, existing operations or facilities meet established standards, but there is a compliance deadline in the future, after which the condition will be in noncompliance unless addressed" (20:Atch 4).

11. Level III Projects: "Projects and services that are important but are not related to an imminent compliance deadline" (McCarthy, Atch 4). Categories include (but are not limited to) pollution prevention, waste minimization, and asbestos removal (20:Atch 4).

12. Major Command (MAJCOM): "A major subdivision of the Air Force that is assigned a major part of the Air Force mission. A MAJCOM is directly subordinate to HQ USAF" (7:9). There are two types of MAJCOMs: operational and support. Operational MAJCOMs directly support strategic, tactical and defense forces. Support MAJCOMs provide supplies, weapons systems, materiel and other services. Air Force bases are subordinate to MAJCOMs (7:9).

13. Multiple Criteria Decision Model (MCDM): A mathematical technique which assists a decision maker in choosing a solution from several alternatives based upon multiple criteria (3:2-3).

14. Objective Criteria: "Expressing or involving the use of facts without distortion by personal feelings or prejudices" (36:785).

15. Payback Period: The period of time it takes for ". . . an investment to pay for itself from benefits, revenues, or savings" (9:58).

16. Subjective Criteria: Criteria determined by the personal and experiential values of an individual (36:1151).

Scope and Limitations

The scope of research was first narrowed by focusing on one of the four categories of environmental projects: Level III. Within this category, research was further confined to pollution prevention projects. The Air Force already funds all Operations & Services and Level I projects, and aggressive commanders may apply other base funds toward Level II projects (19:3). Level III projects have not yet been funded on a large scale, and a prioritization model for these projects has potential for application, especially at the MAJCOM level. When research began in late 1991, pollution prevention projects were considered Level III requirements. They are now being given increased attention, and additional funding for pollution prevention projects is more readily available. This change caused research to be narrowed further to the prioritization of pollution prevention projects.

The scope of research was confined to major commands with bases in the United States. The list of major commands contacted in this research is as follows: Air Combat Command (ACC), Air Force Materiel Command (AFMC), Air Force Space Command (AFSPACECOM), Air Mobility Command (AMC), Air Training

Command (ATC), and Pacific Air Forces (PACAF). Contact was established to identify characteristics to be considered when evaluating pollution prevention projects. AFMC was selected as the MAJCOM for which a tool would be developed, and all projects evaluated were taken from bases within this command.

Research was conducted within AFMC because of the large scale and variety of industrial processes performed in this command. For example, repair and maintenance of aircraft, purchase and use of advanced composites, and neutron radiographic testing are all essential missions of AFMC (21:4-5). Industrial processes are the foremost area of concern regarding pollution prevention (19:Atch 8-1). AFMC performs these industrial tasks for all major commands and therefore has a great potential for identifying pollution prevention projects. Types of pollution prevention projects within AFMC extend from the inception of systems to the improvement of industrial, maintenance, and cleanup processes (19:Atch 8-5). For these reasons, three bases from AFMC were selected to provide project data. These bases were Wright-Patterson AFB, Ohio; Hill AFB, Utah; and McClellan AFB, California.

Overview

Although environmental funding has increased in the Department of Defense, there is still a shortfall in the financial resources needed to meet environmental demands. Chapter I examined the current funding situation in the Air Force and

proposed a methodology for prioritizing pollution prevention projects. Chapter II reviews current procedures available to set priorities among multiple alternatives. Since these decisions are based on a number of different criteria, the standard practice of using various Multiple Criteria Decision Making (MCDM) techniques is also examined. A critique of the current and standard practices is given, resulting in a decision as to which method to use. Chapter III discusses the methodology used to develop the decision model. Chapter IV applies and analyzes the new methodology by comparing lists of prioritized projects prepared by the decision makers with the same list prioritized by the new MCDM. Chapter V summarizes the research, draws conclusions based on the findings, and offers recommendations for further research.

II. Literature Review

Introduction

This chapter explores standard techniques used in MCDMs as well as current models used by the Air Force. Standard methods include *distance-based*, *outranking*, and *value-based* techniques. Each technique is critiqued with the aid of case studies which draw comparisons between these models. MCDMs used by the Air Force can be divided into three groups: *professionally developed*, *individually developed*, and *subjective*. Examples of each are reviewed and critiqued. Finally, the MCDM which is most appropriate for this research is selected.

Standard Methods

Multicriteria decision making takes place in an "environment where multiple factors are to be considered in making the final selection" (31:223). As factors increase and decisions become more difficult, a systematic or quantitative approach is recommended (31:198). Three of the most common MCDMs are reviewed below, and case studies illustrate the strengths and weaknesses of each.

Distance-Based Technique. *Distance-based* techniques ". . . use the concept of distance to choose a satisficing solution" (8:135). A satisficing solution is a decision that meets desired criteria, but is not necessarily the optimum choice

(29:159). Compromise programming and cooperative game theory are two different types of distance-based techniques.

Compromise programming chooses the alternative that minimizes the distance between itself and the ideal solution (8:133-136). The ideal solution, however, does not always exist (11:20). For example, assume that two alternatives are graded on a scale from one to ten, where ten is the ideal score. If alternative A receives a score of six and alternative B receives a two, then A is the best choice because the distance between its score and the ideal is less than alternative B's.

The displaced ideal model (DIM) is a special type of compromise programming which defines the ideal solution to be a composite of the best outcomes in a number of decision criteria. Continuing the example from above, let project A and B be graded in three categories as shown in Table 2-1.

Table 2-1

DIM Example of Compromise Programming

Alternative	Criterion #1	Criterion #2	Criterion #3	Cumulative Score
A	6	3	7	16
B	2	6	4	12

The Displaced Ideal Model establishes the *ideal* alternative as one having a score of 6, 6, and 7 in criterion #1, ? ˙ . and #3, respectively. Alternatives A and B are both compared to this composite of ideal scores. The alternative closes to the ideal is the optimal choice. In this case, alternative A is preferred. The DIM can score alternatives in objective and subjective criteria. Subjective criteria can be graded in ". . . dollars, points, degrees, rank, and other units of measurements" (38:197). This model treats both types of data equally without skewing results (38:197). Criteria which are dependent or independent are also addressed by the DIM (38:162-169).

Cooperative game theory MCDMs use the concept of attempting to meet as many of the objectives as possible -- even when objectives compete against one another. For example, if it is desirable to choose an alternative which has a maximum benefit, it may also be the most costly alternative and therefore unsatisfactory. Cooperative game theory establishes a minimum acceptable level for each of the competing criteria. The best solution is defined as the one that maximizes the distance from these minimums (11:19).

Outranking Techniques. "These techniques use outranking relationships among alternatives to select the most 'satisficing' alternative" (8:134). *Outranking* relationships refer to conducting pairwise comparisons of alternatives: one alternative *a* outranks another alternative *b* if ". . . *a* is better than *b* in a sufficient

Table 2-2

Cooperative Game Theory Example

Criterion	Minimum Acceptable Score	Project/Alternative			
		A		B	
		Score	Distance	Score	Distance
1	15	17	2	16	1
2	20	20	3	23	3
3	5	10	5	7	2
Total Distance			10		6

(weighted) number of criteria, and if *a* is not too much worse than *b* in any other criteria" (8:135). To illustrate, assume a man is going to purchase a car and he has narrowed his decision to two cars. He has decided to base his decision on two criteria: gas mileage and cost. The first car gets better gas mileage, but has a much higher price. In other words, it is better in one criterion, but much worse in the second. Therefore, the pairwise comparison between the two cars results in the selection of the second car.

When using outranking techniques, comparisons are made using four levels of preference: strict preference, indifference, weak preference, and incomparability (8:134). As the pairwise comparisons are made, alternatives may be prioritized.

ELECTRE I and ELECTRE II are examples of outranking techniques. ELECTRE I is a method of ranking alternatives by comparing each possible choice to all others one at a time. "The idea in ELECTRE I is to choose those systems that are preferred for most of the criteria and do not cause an unacceptable level of discontent for any one criteria" (11:16). The results are a partial ordering of alternatives. ELECTRE II uses the results of ELECTRE I to finalize the prioritization (11:19). Other outranking techniques exist which prioritize alternatives depending on the type of information available (28:54-57).

Value-Based Technique. *Value-based* techniques use the concept of utility, where utility is defined as ". . . the subjective benefit derived by the decision maker from the achievement of the stated goods or objectives" (11:19). The degree of utility given to each criterion by the decision maker is incorporated into the overall value. In other words, it uses a decision maker's preferences in rating a solution. One of the *value-based* techniques is referred to as multiattribute utility theory. In this technique, mathematical assumptions preclude the use of attributes that are dependent on one another. Attributes must be independent of each other and must also be utility-independent. Once these conditions are met, the alternative receiving the highest overall utility is the best choice (11:19).

Critique. *Distance-based*, *outranking*, and *value-based* techniques are evaluated in two articles: "Multicriteria Analysis of Hydropower Operation," from

the Journal of Energy Engineering (8:132-151), and "Multiobjective Approaches to River Basin Planning," from the Journal of Water Resources Planning and Management (11:13-27). The first article uses these MCDMs to examine different methods of operating hydropower systems with conflicting objectives associated with power production, economics, and ecology (8:133). The second article analyzes different water development strategies with MCDMs, and compares the various MCDM techniques (11:13).

The authors of "Multicriteria Analysis of Hydropower Operation" state that the three MCDM approaches used were satisfactory in solving these types of conflicts. They further surmise that subjective criteria were best handled by the *outranking* technique or the *value-based* method (8:150-151). In the second article the authors are more thorough in their analysis of the different MCDMs. They state that despite ELECTRE I's superior handling of qualitative (subjective) data, it often violates utility theory axioms. Their criticism of distance-based MCDMs is that they compare ". . . alternatives to an infeasible one, while cooperative game theory compares alternatives to a feasible, but undesirable one" (11:20). Finally, the multiattribute utility theory deals only with independent attributes. The authors summarize by saying that no single technique is best. When considering different types of criteria, a combination of techniques is recommended (11:26).

Table 2-3 summarizes of the advantages and disadvantages of the standard techniques just discussed.

Table 2-3

Professionally Developed Models

Technique	Example	Advantages	Disadvantages
Distance-Based	Compromise Theory	Addresses subjective and objective input Addresses independent and dependent input	Compares alternatives to an infeasible (perfect) solution
	Cooperative Game Theory	Addresses subjective and objective input Addresses independent and dependent input	Compares alternatives to an undesirable (minimally acceptable) solution
Outranking	Pairwise Comparison	Addresses subjective and objective input	Violates utility theory
Value-Based Technique	Multiattribute Utility Theory	Addresses subjective and objective input	Dependent criteria not addressed

Air Force Methods

The Air Force uses several different MCDMs to prioritize alternatives in many fields. Two *professionally developed* models include the Defense Priority Method (DPM) and the Performance Based Model (PBM). An *individually developed* model was created at McClellan AFB to assist in localized decision making. A third category, *subjective ranking*, is commonly used by the Air Force at all levels to establish funding priorities (1:22 Jan 92; 17:19 Mar 92).

Professionally Developed. The first professionally developed model, the DPM, was developed for Air Staff by a professional management team. It was designed to prioritize projects identified through the Air Force Installation Restoration Program (IRP). Air Force policy requires its most difficult environmental problems to be addressed first (25:x).

The DPM was designed ". . . to assist decision makers in identifying priorities for remedial action" (25:x). Sites are rated by a linear algorithm based on their risk to human health and environmental well being. Subscores are calculated for each of the potential paths, or combinations of paths contaminants may take to reach receptors (25:xi). To illustrate, suppose a contaminant is transported by surface water (a transport pathway) and ingested by a human being (a receptor). Subscores are calculated for the probability of the water pathway carrying the contaminant and for the probability that the human receptor ingests it. These probabilities are

multiplied, summed with other such products of possible paths and receptors, and weighting factors are incorporated to determine a final score (25:103). However, the DPM does not consider all criteria that might contribute to the risk of the site. Scores are intended to be one of many factors to consider in making the final decision. The amount of attention given to the DPM score is subjective and depends on other considerations ". . . such as regulatory requirements and program efficiencies" (25:3).

The second professionally developed MCDM reviewed was the PBM. It was designed as a tool for the Air Force to select the contractor with the best performance record to construct facility systems (16:176). The PBM is a computerized mathematical model which uses DIM concepts (a *distance-based* technique). This model takes advantage of the DIM's ability to work with quantitative (objective) and qualitative (subjective) data, and dependent and independent criteria (16:162; 38:162-169). It also takes advantage of a computer's ability to manipulate and maintain large volumes of data. After contractors' performance data are entered into the computer program, the PBM identifies the best performance in each of the criteria. As with the DIM, the ideal choice is defined as a composite of the best outcomes in each of the criteria. Contractors are then measured against the ideal performance scores, and the one closest to the ideal is selected (38:156). Flexibility is available in this model because it allows the decision

maker to vary weights assigned to criteria as well as the ability to select and change the criteria themselves.

Individually Developed. McClellan AFB created a decision model using a computerized spreadsheet program (33:31 Jan 92). In this MCDM, points were assigned based on environmental and economic considerations to determine which projects to execute first (18:1). Environmental and economic criteria were also used at the MAJCOM level, but at base level information was much more detailed. Economic factors used by McClellan included net present value (NPV), return on investment (ROI), and annual savings. Environmental considerations consisted of the potential for breaking environmental laws, the hazard posed, and the potential for environmental benefit (32:20-21 Apr 92).

Once data for projects were gathered and entered into the computer spreadsheet, prioritization was made possible with a unique application of utility theory. Decision makers weighted criteria using a variable point scale. For example, projects received over 100 points in the ROI category, but only 15 points in the environmental benefit category (32:20-21 Apr 92). In this fashion, more "utility" was given to ROI than environmental benefit. Other than the subjectively-assigned point scales, data used in this model were kept as objective as possible. McClellan's MCDM then prioritized its environmental projects based on overall scores (32:20-21

Apr 92). A sample chart of McClellan's environmental projects and scores is provided at Appendix A.

Subjective Ranking. Subjectivity is present in decision making at every level of Air Force management: Air Staff, MAJCOM, and base level. The Air Staff sets its funding policies based on the experience and values of its leaders. For example, AFMC recently submitted hundreds of environmental compliance projects for funding. Air Staff chose to fund only those projects which documented the potential for recovering investment costs within three years. The decision to allocate funding based on a three-year payback period can be easily justified, but was largely subjective (17:14 May 1992).

In addition to following Air Staff guidance, MAJCOM decision makers incorporate subjectivity into their own decision making. Recently AFMC was faced with the task of prioritizing pollution prevention projects for funding. The Pollution Prevention Division Chief gave first priority to projects involving ozone layer depleting substances (OLDS). Second priority was given to projects with less than a three-year payback period, and third priority to projects that had an indirect impact on pollution prevention. The Division Chief's assistant ranked the same projects in a different manner. Projects which determined the amounts of hazardous substances used by AFMC were considered to be top priority by the assistant. OLDS projects and projects with less than a three-year payback period were given second and third

priority, respectively. A final ranking was agreed upon by the chief and his assistant after considerable discussion and compromise (17:14 May 92).

An example of subjective decision making at base level was observed at Hill AFB, Utah. Five criteria were considered by Hill's environmental programmer. These criteria, in order of importance, were: the length of time before compliance deadlines were reached, political interests, community relations, economic considerations, and the potential for a project to meet future compliance requirements (13:23 Apr 92). In the process of prioritizing projects, these five criteria were considered in combination with a pair-wise comparison with each of the projects. In short, the programmer reviewed one project, compared it to another project, and decided which was more important based on his own criteria and judgement The decision was based on experience, familiarity with the project, and how the project rated in each of the five criteria (13:23 Apr 92).

Each level of management (Air Staff, MAJCOM, and base level) incorporated some degree of subjectivity in prioritizing projects. Priorities, in turn, determine which projects receive funding.

Critique. If a decision maker has access to quantifiable, verifiable data on each of the alternatives, professionally developed models are very useful. The DPM mathematically analyzes the data and offers input for the decision maker to consider. However, most decisions require the consideration of subjective information which

this model is unable to incorporate. It is up to the decision maker to take all other factors into account and use his or her best judgement to make a final selection.

The Performance Based Model also uses mathematical equations to evaluate alternatives. By taking advantage of the same concepts used in the DIM, the PBM is able to incorporate both objective and subjective data. In addition, it can manipulate criteria, whether dependent or independent, without degrading the accuracy of the solution. Equations used in this model are labor intensive because each alternative must be evaluated under each criterion. Without access to a computer, these equations would be difficult to solve. However, once programmed into a computer, the equations are no longer cumbersome. This model also allows flexibility by allowing the decision maker to choose and weight his own criteria.

The individually developed model used at McClellan is tailored for the specific needs of that base. It attempts to keep subjectivity to a minimum. By adding the desired weight to a specific criterion, this model meets the specific goals of its installation. Manipulation of data is simplified in terms of speed and flexibility with the aid of this computer model. A potential source of error is introduced to this model, however, in its treatment of dependent data. For example, many of the criteria used by McClellan are interrelated. To illustrate, an alternative with a high annual savings will generally have a high ROI. This model does not address the fact that input from one criterion may drive the input to another. In effect, the annual

savings is measured to some degree in two criteria and the relationship is unknown (38:162-165).

Subjective methods are appropriate when the decision involves few alternatives rated in few criteria. However, funding decisions regarding environmental projects are generally more complicated with many projects and criteria to consider. The subjective method employed by Hill AFB included pairwise comparisons to rank projects. However, without a systematic scoring method, it is not always possible to rate all projects equally in each of the chosen criteria.

A summary of the advantages and disadvantages of Air Force techniques is given in Table 2-4.

Summary

This research focuses on the development of a tool for MAJCOMs to prioritize numerous environmental projects. The methodology chosen must be able to address objective and subjective data. It must also be able to incorporate dependent and independent criteria in such a way that interdependence does not skew results. Since the model will be used by a MAJCOM, it must be able to handle large volumes of data. Flexibility and maintainability are needed to give managers the ability to make minor changes and updates in minimal time.

The only model unable to address subjective data was the DPM. All other techniques were able to incorporate both subjective and objective input. Because of

Table 2-4

Air Force Models

Technique	Example	Advantages	Disadvantages
Professionally Developed	Defense Priority Model	Provides objective data	Subjective input not addressed
	Performance Based Model	Addresses subjective and objective input Addresses dependent and independent criteria Comparison made to best scores achieved Easy maintainability Handles high volume of data Flexibility with goals and objectives Speed	
Individually Developed	McClellan AFB Method	Addresses subjective and objective input Easy maintainability Handles high volume of data Flexibility with goals and objectives Speed	Dependent criteria not addressed
Subjective	Air Staff, MAJCOM, Hill AFB Method	Addresses subjective and objective input Flexibility with goals and objectives Speed (with little data)	Inconsistent grading system Slow with high data volume

the requirement to handle dependent as well as independent criteria, *outranking* and *value-based* techniques were not selected for use in the development of a model. The DIM and PBM models, both *distance-based* techniques, made corrections for problems associated with using dependent data, while the *individually developed* model assimilated dependent data without accounting for interrelated problems. Subjectivity presented a problem when handling large volumes of data. The computer models, had the capacity to handle large volumes of data which was easily updated, and offered increased flexibility.

Based on the analysis of these models and the needs of this research, a model similar to the PBM was developed. A computerized spreadsheet was devised which enhances flexibility and maintainability. It also has the ability to handle subjective and objective data as well as independent and dependent criteria all on a large scale.

III. Methodology

Overview

This chapter outlines the procedure for developing a new technique to rank pollution prevention projects for an Air Force MAJCOM. This technique is referred to as the DIM Alternative Ranking Technique (DART). DART employs concepts from the Displaced Ideal Model in a manner similar to that of the Air Force's Performance Based Model. Because the new model makes use of a computerized spreadsheet, the first section of this chapter is devoted to the development of the spreadsheet framework. A sample application of DART is given to further explain DIM theory and concepts associated with the various steps involved. Once this is accomplished, a method to identify potential criteria in which to evaluate each project is discussed. Next, the procedure is outlined for data collection on actual pollution prevention projects from several AFMC bases. Finally, DART is evaluated on its ability to reflect the decision maker's objectives.

Spreadsheet Development and DIM Theory

The steps to develop DART are outlined in this section. Steps associated with the main concepts of DIM are discussed in greater detail. To aid in the explanation of the theory, fictional data is used for five projects. The five sample projects are evaluated in four criteria as shown in Table 3-1. Each project is taken

the sequence of equations used in the Displaced Ideal Model process. These steps are incorporated into DART, concluding with a prioritized list of the five sample alternatives.

Step One. This step introduces several concepts used in the Displaced Ideal Model and in DART. First, the ideal alternative is identified and explained. This is followed by a discussion of subjective and objective data and how they are incorporated into this model.

Step 1. Enter data into the original data matrix and identify the best number in each column.

Table 3-1

Original Data Matrix

Project/ Alternative	Cost ($1000s)	Payback Period (years)	Environmental Contribution (1=Low, 10=High)	Political Attention (1=Low, 10=High)
I	-12	1.0	3	10
II	-5	0.5	2	1
III	-10	3.5	6	2
IV	-17	3.0	10	7
V	-25	5.0	8	5

The Ideal Alternative. Once the necessary data is obtained on all projects, the best value in each criterion is determined (38:194). Depending on the

criteria, the best value may be either the highest or lowest number recorded (38:159). For example, a lower Payback Period value implies that the project will pay for itself sooner and is preferable to higher values (9:58). For Environmental Contribution, however, the highest score is desired. Cost, in this example, is unique because there are two methods of finding the best value. First, costs may be entered as negative values, such as in Table 3-1, and the maximum value (i.e., the value nearest zero) is preferred. Alternatively, costs may be entered as positive numbers, and the smallest value would be preferred (38:155). In Table 3-1, the best value in each column is shaded. The ideal alternative is then comprised of the values in the shaded cells. Although the ideal does not exist, all projects are compared to this ideal.

Objective and Subjective Data. Objective and subjective criteria are both used in this example. The column headings of Cost and Payback Period represent objective criteria. Although estimates are involved in determining such values, these data are relatively free of personal feeling and judgement. Environmental Contribution and Political Attention, however, are subjective. For the purposes of discussion, subjective criteria are scored on a ten-point scale where one is low and ten is high. Points are assigned by the decision maker or guidelines may be developed by the decision maker to allow others to score projects in these areas.

Step Two. Table 3-2 is generated from Table 3-1 and addresses three more subjects important to DART: degrees of closeness, dependent criteria, and fuzzy sets.

Step 2. Divide each value in Table 3-1 by the best number in its column. Enter the new value in Table 3-2, and sum the column.

Table 3-2

Degrees of Closeness

Project/ Alternative	Cost	Payback Period	Environmental Contribution	Political Attention
I	2.40	2.00	0.30	1.00
II	1.00	1.00	0.20	0.10
III	2.00	7.00	0.60	0.20
IV	3.40	6.00	1.00	0.70
V	5.00	10.00	0.80	0.50
SUM	13.80	26.00	2.90	2.50

Degrees of Closeness. The term *degrees of closeness* explains how data measured on different scales (dollars, years, level of attention, etc.) may be integrated without distorting results (38:197). In this step, each data element from Table 3-1 is divided by the *best* or *ideal* number in its column. This gives a new value representing the project's nearness (distance) to the best number in each of the

criteria. It is known as the *degrees of closeness* and is represented by the letter *d*. Table 3-2, above, is called the Degrees of Closeness Table. Column sums are also shown in Table 3-2 and are used in the following step. The sum is represented by *D*.

When the division operation is performed, all units are cancelled. The result is that all data in Table 3-2 is unitless. For example, the cost of Project I as shown in Table 3-1 is $12. Dividing $12 by the best cost value, $5, gives the value 2.4. The unit of dollars is cancelled in the division. This allows data from all columns (whether subjective or objective) and from all scales (dollars, years, etc.) to be compared on a unitless scale.

Dependent Criteria. In addition to mixing objective and subjective criteria, dependency between criteria is sometimes overlooked. This is a potential source of error with some MCDMs. Dependency is present when scores in one criterion affect the scores in another criterion. To illustrate, assume that Payback Period is dependent on Cost in such a way that an expensive alternative automatically has a high payback period. The result is that a poor value in one column generates a poor value in a second column. Cost, therefore, has an impact in more than one column, and the relationship between these columns is unknown. The method in which DIM addresses this potential source of error is to look at each column (each criterion) as a distinct set of data (38:162-165). In the following steps, mathematical operations are performed on columns before combining results to

determine priorities. The data in each column is referred to as a *fuzzy set*, the next topic of discussion.

Fuzzy Sets. A *fuzzy set* is defined as an array of numbers derived from another array whose limits are not clearly defined (15:265). In this case, values in each column from Table 3-2 are derived from corresponding columns in Table 3-1. The table columns represent arrays. Because the values in Table 3-1 can change as often as project information changes, limits (high and low values) from each column in Table 3-1 may be redefined. By focusing on each column individually, possible links of criteria dependency are broken (38:162-164). In other words, if Cost does have an impact on Payback Period, it does not affect the final outcome of DART.

Steps Three and Four. The next two steps in the DIM procedure are presented without in-depth explanation. The originator of the Displaced Ideal Model, Milan Zeleny, presents a detailed discussion of each of the following steps in his book, Multicriteria Decision Making (38:152-197). Data from the example is taken through each of the mathematical operations.

Step 3. Divide each element, d, in Table 3-2 by the sum, D, and verify calculations by checking that the sum of each new column equals 1.0000 (Table 3-3).

Table 3-3

Degrees of Closeness Divided by Column Sums

Project/ Alternative	Cost	Payback Period	Environmental Contribution	Political Attention
I	0.1739	0.0769	0.1034	0.4000
II	0.0725	0.0385	0.0690	0.0400
III	0.1449	0.2692	0.2069	0.0800
IV	0.2464	0.2308	0.3448	0.2800
V	0.3623	0.3846	0.2759	0.2000
Verify Sum	1.0000	1.0000	1.0000	1.0000

Step 4. Normalize data from Table 3-2 by multiplying each value by the natural log (ln) of itself: d/D * ln(d/D). Then sum each column (Table 3-4).

Table 3-4

Normalized Data

Project/ Alternative	Cost	Payback Period	Environmental Contribution	Political Attention
I	-0.3042	-0.1973	-0.2347	-0.3665
II	-0.1902	-0.1253	-0.1844	-0.1288
III	-0.2799	-0.3533	-0.3260	-0.2021
IV	-0.3451	-0.3384	-0.3671	-0.3564
V	-0.3678	-0.3675	-0.3553	-0.3219
SUM	-1.4873	-1.3813	-1.4675	-1.3756

Step Five. Step five introduces the concept of entropy. The amount of entropy a criterion has affects the level of emphasis that criterion has on the final outcome. This section also explains a variable used by DIM equations which facilitates the flexibility desired by decision makers regarding the number of alternatives.

Step 5. Calculate the entropy, *e(d)*, for each column with the following equation:

$$e(d) = (-1) * (\text{Table 3-4 Sum}) / \ln(m)$$

The variable *m* refers to the number of alternatives being ranked. Then calculate the total entropy, *E*, by summing this row of values (Table 3-5).

Table 3-5

Entropy Values

	Cost	Payback Period	Environmental Contribution	Political Attention	Sum of Row (E)
e(d)	0.9241	0.8586	0.9118	0.8547	3.5492

Entropy. Entropy is a term used to describe the amount of information available to the decision maker, and, in this example, is represented by the numbers in Table 3-5 (38:189). As a criterion's entropy increases, it has greater influence on the final decision and is similar to adding weight to a criterion (38:168).

However, there is an inverse relationship between the e(d) value shown in Table 3-5 and the amount of entropy, or amount of information, present. As e(d) increases, less entropy and less information are available, and a criterion has less impact on the final prioritized list. In Table 3-5, all entropy values are rather close, but Political Attention has the lowest e(d) value and therefore has the greatest entropy.

Flexible Number of Alternatives. As seen in the equation to derive e(d), a variable is assigned to the number of alternatives being prioritized (38:155). By making this number a variable, decision makers are granted the flexibility to add or remove projects from the decision model. The number of projects is referred to by the variable *m* (38:194).

Steps Six and Seven. The next steps discuss criteria selection and assigning weights. Both subjects further demonstrate the adaptability of the Displaced Ideal Model.

Criteria Selection. The number of criteria is another variable which, again, enhances the decision maker's flexibility. Here, the variable *n* is used to denote the number of criteria chosen. The decision maker is allowed to increase, decrease, or substitute one criterion for another according to his objectives. A method of selecting criteria is explained in the next section.

Step 6. Incorporate the number of attributes (criteria) used with the following equation: (1/(n-E))*(1-(e(d)) (Table 3-6).

Table 3-6

Incorporation of the Number of Attributes

Cost	Payback Period	Environmental Contribution	Political Attention
0.1683	0.3138	0.1956	0.3222

Weight Assignment. Once criteria are chosen for use in the model, weights are assigned on a percentage basis. However, there are reasons a decision maker may want to redistribute weights upon reviewing priorities generated by DART. First, there is the fact that entropy also influences the level of emphasis of each criterion. It is not necessarily possible to determine the extent of entropy's involvement until after all the steps are completed. If the priorities generated by DART are inconsistent with those of the decision maker, these weights may be adjusted (38:187-194). Weights may also be adjusted to reflect a change in strategy. If the decision maker learns of a new criterion to be considered, or an old criterion suddenly becomes obsolete, this model grants the flexibility to make these updates.

Step 7. Assign weights to criteria. (For the purpose of illustration, this is done arbitrarily, but would normally be done in consultation with the decision maker.) Ensure the sum of weights equals 1.00 (Table 3-7).

Steps Eight through Twelve. The next five steps are performed as prescribed by DIM procedure (38:152-197). Data from the example is carried through each of the mathematical operations.

Table 3-7

Criteria Weights

Cost	Payback Period	Environmental Contribution	Political Attention	Verify Sum
0.05	0.30	0.40	0.25	1.00

Step 8. Incorporate assigned criteria weights by multiplying Table 3-6 values by their corresponding criterion weight in Table 3-7 and sum (Table 3-8).

Table 3-8

Incorporation of Criteria Weights

Cost	Payback Period	Environmental Contribution	Political Attention	Sum
0.0084	0.0941	0.0783	0.0806	0.2614

Step 9. Normalize the weight factors chosen by dividing Table 3-8 values by the sum in Table 3-8 (Table 3-9).

Step 10. Compute the Deviation Table by subtracting d (Table 3-2 values) from 1 (Table 3-10).

Step 11. Compute individual distances from the ideal score in each column by multiplying Table 3-10 values by the corresponding value in Table 3-9 and take the absolute value. Then sum the rows to determine the project's total distance from the ideal (Table 3-11).

Step 12. Arrange the projects in order of priority, from lowest distance value to highest (Table 3-12).

Table 3-9

Normalized Weights

Cost	Payback Period	Environmental Contribution	Political Attention
0.0322	0.3602	0.2994	0.3082

Table 3-10

Deviation Table

Project/ Alternative	Cost	Payback Period	Environmental Contribution	Political Attention
I	-1.4000	-1.00	0.70	0.0000
II	0.0000	0.0000	0.8000	0.9000
III	-1.0000	-6.0000	0.4000	0.8000
IV	-2.4000	-5.0000	0.0000	0.3000
V	-4.0000	-9.0000	0.2000	0.5000

Once projects are prioritized, the decision maker is able to evaluate the outcome of these mathematical steps. The best project is the one with the lowest distance value -- the one closest to the ideal.

Identification and Selection of Criteria

In the previous section, five projects were evaluated in four criteria. Although the criteria selected for the example were chosen to illustrate several

Table 3-11

Distance Table

Project/ Alternative	Cost	Payback Period	Environmental Contribution	Political Attention	Sum/ Distance
I	0.0451	0.3602	0.2096	0.0000	0.6148
II	0.0000	0.0000	0.2395	0.2774	0.5169
III	0.0322	2.1610	0.1198	0.2466	2.5595
IV	0.0773	1.8008	0.0000	0.0925	1.9706
V	0.1288	3.2415	0.0599	0.1541	3.5843

Table 3-12

Prioritized Projects

Priority	Project/ Alternative	Sum/ Distance
1	II	0.5169
2	I	0.6148
3	IV	1.9706
4	III	2.5595
5	V	3.5843

concepts, the identification and selection of criteria should reflect the decision maker's goals and objectives. This section outlines a method to identify potential criteria for use in DART.

A starting point in identifying criteria is to poll experts in the field of interest, i.e., USAF Environmental Managers. To broaden the perspective and diversify the potential list of criteria, requests for input should be addressed to several informed individuals at different levels of management. Although not exact, this procedure is similar to the Delphi technique, a method of using input from qualified people to arrive at a decision or consensus (31:123).

Once responses are received from the experts, a thorough list of criteria are available. Decision makers may then choose any combination of criteria from this list or add new items. The result is a final list of criteria in which to evaluate projects. Once criteria are selected, data collection may begin.

Data Collection

Data collection is limited to AFMC in this research and is required at two levels of management: headquarters and base level. The ultimate decision makers at AFMC Headquarters must select the criteria and the weighting factors to apply to each. Base level managers must provide data on the projects within the criteria specified. Actual project data from several AFMC bases should be incorporated into DART. This allows evaluation of DART on its ability to work with actual data. Collecting data on projects from different bases will require decision makers to integrate projects from these bases in the final priorities. This simulates the competition that exists for funding between bases.

Data collection at base level involves objective and subjective data. Objective data should be recorded as a means of providing AFMC managers information that might affect their decision. Data collection on subjects requiring judgement, subjective data, requires guidance for managers at different bases to grade projects similarly.

Once data from bases is gathered, it may be entered into DART. However, weights are still required from AFMC decision makers before DART can generate a prioritized list of projects. Initial weights for each criterion should reflect MAJCOM objectives, but adjustments may be necessary due to the nature of DART. This will require additional data collection from the decision makers. The final data required from MAJCOM is a list of all projects which is prioritized by the decision makers using their normal methodology. This list will be used in the evaluation of DART.

Evaluation

Once priorities are generated by DART, the evaluation process may be initiated. The first step entails a comparison of DART's priorities to the decision maker's. If projects are ranked consistently by both, this implies that DART adequately reflects the goals and objectives established by the decision maker and the process is complete. However, if this ranking is inconsistent with the decision maker's goals or objectives, different actions may be taken. First, weights may be adjusted to add emphasis to certain criteria. A second step is to reduce the entropy

present in a given criterion. For example, to reduce the impact of Cost, it would be possible to convert project costs to another scale. Projects costing less than $10,000 could be assigned a value of one, costs between $10,000 and $100,00 could be given a value of two, and higher priced projects could be given a three. The overall effect is that the entropy associated with Cost is reduced. Finally, regardless of the outcome, varying weights may be used to accommodate and experiment with different management strategies. If Political Attention shifts from one type of project to another, scores themselves may change along with the criterion. Thus, this model allows the decision maker to experiment and generate prioritized lists using different values and different weights (38:185). Following these adjustments, the process of assigning weights starts again until objectives are adequately reflected in the priorities generated by DART. This process of refining DART is illustrated in Figure 3-1.

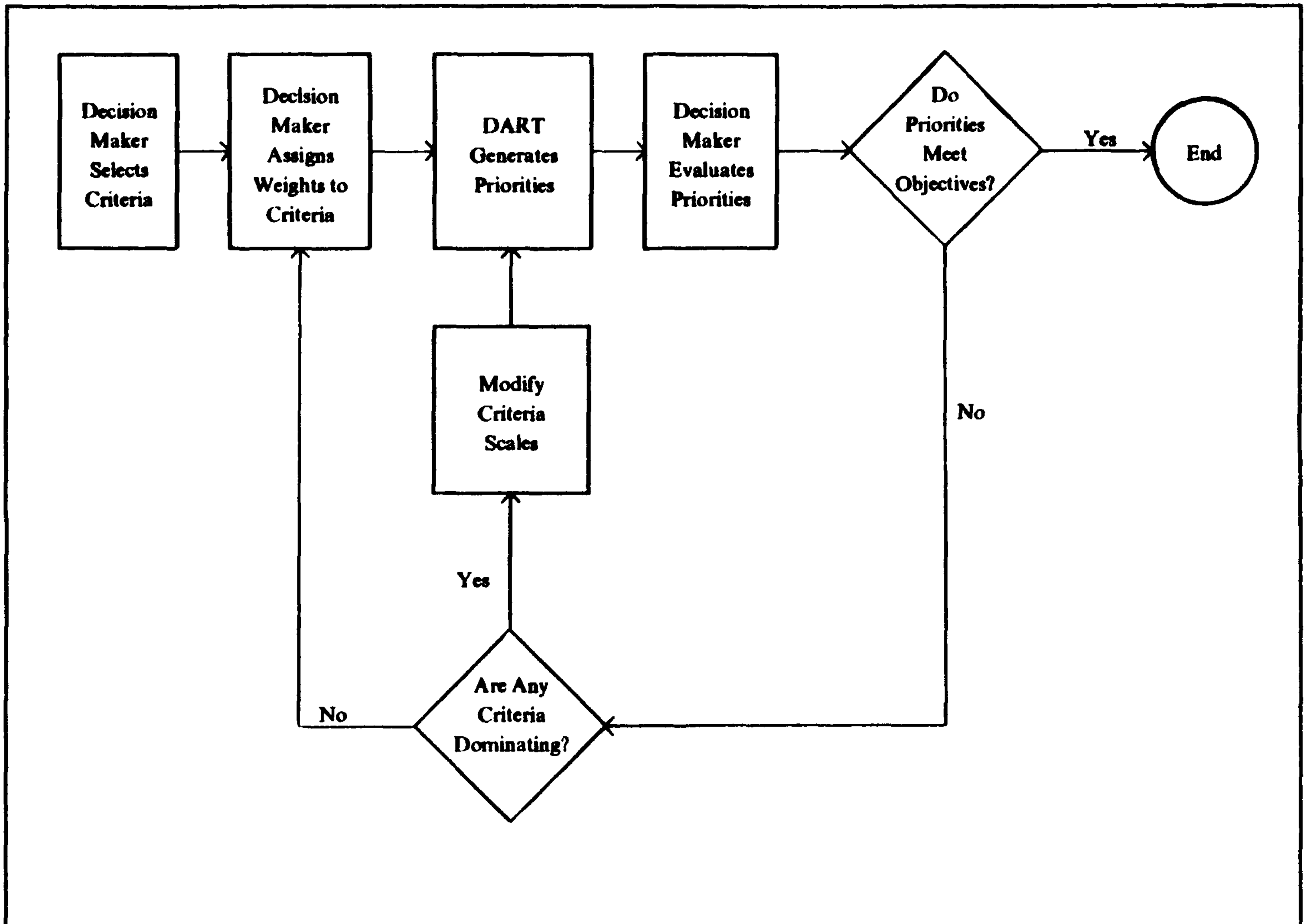


Figure 3-1. Flowchart of DART Refinement Process

IV. Analysis and Findings

Introduction

Chapter IV reviews and analyzes the application of DART to pollution prevention projects from AFMC to find if it meets requirements. First, it explains the approach taken to identify criteria for the model, and how criterion scoring systems were devised. Next, it reviews the data collection process, both at the bases and at AFMC Headquarters. Finally, it evaluates whether or not DART meets AFMC's expectations by comparing prioritized lists generated by DART to those of the AFMC decision makers.

Criteria and Scoring Systems

Before data collection on projects began, it was necessary to identify the criteria in which the projects were to be evaluated. This process began by compiling a preliminary list of candidate criteria by conferring with local Air Force personnel with experience in the environmental field. Next, telephone contact was established with Air Force environmental managers from a range of management levels (Appendix B). Additional criteria were solicited by asking these individuals for criteria they would use. The written request, including the original list of criteria and other attachments, is shown at Appendix C. As new criteria were identified, they

were added to the list of criteria in which to evaluate pollution prevention projects. The final list of attributes is shown in Table 4-1.

Table 4-1

List of Potential Criteria

Financial Considerations	Political Considerations	Other
Total Cost	Attention from Regulators	Safety Risk
Net Present Value	Attention from Public	Health Risk
Payback Period	Attention from Congressional	Contribution to Environment
Base Obligation Rate	Attention from MAJCOM	Base Priority
Ready to Execute	Attention from Local DOD Leaders	Potential for Meeting Future Requirements
Return on Investment	Attention from Air Staff	Is Technology Available?
Savings Generated		Public Relations Contribution
Equitable Distribution in Command		
Equitable Distribution to Programs		

(24:19 Mar 92; 2:10 Mar 92)

Once the list of criteria was determined, scoring systems were needed to evaluate projects before data collection could proceed. For objective criteria, two systems were used: real data and a yes-no scale. However, to score a project in

subjective criteria, such as Attention from Regulators, a grading scale was needed. Two different point systems were used for these criteria: 1 through 10 (low to high) and 0-5-10 (low-medium-high). The proposed grading scales of all criteria were strictly experimental and the scale used for each criterion is shown in Appendix D.

Data Collection

Three AFMC bases were chosen to participate in this research: Wright-Patterson, McClellan, and Hill AFB. Each base provided data on five pollution projects, information on their method of prioritization, and their actual prioritization of the five projects selected. A summary list of all projects and complete project descriptions for all fifteen pollution prevention projects are provided at Appendix E.

Wright-Patterson AFB. The first base to provide data was Wright-Patterson AFB, Ohio. In order of priority, the five projects selected were:

1. Baseline Pollution Prevention Audits,
2. Freon Recovery, Recycling and Equipment,
3. Replace Refrigeration Purge Units,
4. Needleless Intravenous System, and
5. Electronic Imaging System (37:13 Apr 92).

In attempting to collect data on these projects, there were difficulties. First, figures for Net Present Value (NPV), Payback Period, Return on Investment (ROI), and Savings Generated were not available. (This information is not normally requested by AFMC Headquarters.) Also, each of the Political Sensitivity criteria

were given multiple ratings. One project, for example, received three scores under Attention from Regulators. The first score indicated attention from federal regulators, the second from state regulators, and the third from local regulators. The other two bases provided a single, overall value for these types of criteria, so Wright-Patterson's data were converted to average scores. Original data is provided at Appendix F. Priorities for the five projects, shown above, were established by considering the following criteria:

1. Inventory assessment projects,
2. DOD priorities,
3. Potential for future notice of violation (NOV),
4. Base commander objectives, and
5. Waste reduction projects (37:13 Apr).

McClellan AFB. The second base, McClellan AFB, California, used a more comprehensive system to determine priorities. The five pollution prevention projects selected for evaluation are shown below in order of priority:

1. Repelletize/Reuse Spent Plastic Media Beads,
2. Aircraft Corrosion Control Recycle Equipment,
3. Supercritical Fluid Cleaning,
4. Waste Recycle Equipment, and
5. Photopyrolysis Depaint System (32:20 Apr 92).

Because McClellan AFB's system was more thorough, all data was readily available except in subjective areas. The Environmental Programmer who designed the McClellan model graded projects in these areas based on his experience,

familiarity with the projects, and knowledge of McClellan's environmental objectives. Overall priorities were based on the following considerations:

1. Economic factors (Cost, Payback Period, Net Present Value),
2. Whether the project is executable or not,
3. The level of environmental improvement,
4. Level of effectiveness and efficiency,
5. Potential hazard posed, and
6. Potential for violation of present or future law (32:20 Apr 92).

The original data from McClellan is shown in Appendix G.

Hill AFB. Data from Hill AFB was gathered on the following five projects listed in rank order:

1. Phaseout of Ozone Depleting Chemicals,
2. Pollution Prevention Opportunity Assessment,
3. Waste Oil Boiler,
4. Waterfall Desludging Units, and
5. Off-Base Jet Noise Abatement (13:22 Apr 92).

In obtaining data from Hill AFB, two figures under Financial Considerations were not available: NPV and ROI. The Environmental Programmer prioritized the projects by taking the following criteria into consideration:

1. Environmental laws,
2. Political considerations,
3. Community interest,
4. Economic considerations, and
5. Future compliance (13:22 Apr 92).

Project data is found at Appendix H.

Preliminary Data Review

In collecting data from the bases, there were some concerns about the values assigned to the criteria. Therefore, the grading scales used for each criteria were reexamined.

The following four scales were used in the original grading system:

1. 1 through 10,
2. 0-5-10 (low-medium-high),
3. Real data, and
4. Yes-No.

In an attempt to standardize the method of scoring projects, the 1 through 10 scale and the 0-5-10 scale were both converted to a 1-5-10 scale. Also, points were assigned to the Yes-No category (Yes=10, No=1). These conversions are summarized in Table 4-2.

Table 4-2

Score Conversions

Previous Scale	Conversion to 1-5-10 Scale
No, 0, 1, 2, 3	1
4, 5, 6, 7	5
8, 9, 10, Yes	10

In the Real Data category, values were not always available. In such cases, the least desirable score was assumed. For example, under Payback Period, the worst possible score was 30 years. Therefore, if no payback period was estimated for a given project, it was assigned a value of 30-years.

Once these changes were incorporated, the original four categories were reduced to the three categories shown below:

1. 1-5-10 (low-medium-high),
2. Real data, and
3. Yes-No (10-1).

AFMC Data Collection

Following data collection at the three AFMC bases, data collection at the headquarters level began. Information was collected from the decision authorities regarding decisions in the final selection of criteria, project prioritization, and criteria weighting.

Final Selection of Criteria. The Pollution Prevention Division Chief and his assistant were the funding authorities for pollution prevention projects at AFMC Headquarters. After discussion with these decision makers regarding the relevance of the criteria, many items were eliminated. Table 4-3 shows the initial list of criteria, and indicates the final criteria chosen by AFMC. The final criteria selected are also shown in Appendix I.

Table 4-3

List of Criteria

Financial Considerations	Political Considerations	Other
* Total Cost	★ Attention from Regulators	* Safety Risk
Net Present Value	★ Attention from Public	* Health Risk
* Payback Period	† Attention from Congressional	* Contribution to Environment
* Base Obligation Rate	† Attention from MAJCOM	* Base Priority
* Ready to Execute	★ Attention from Local DOD Leaders	Potential for Meeting Future Requirements
Return on Investment	† Attention from Air Staff	Is Technology Available?
Savings Generated		Public Relations Contribution
Equitable Distribution in Command		
Equitable Distribution to Programs		

* Criterion Selected
★ Criterion Combined under New Heading: Local Attention
† Criterion Combined under New Heading: National Attention

Under Financial Considerations, NPV, ROI, Savings Generated, and both of the Equitable Distribution criteria were excluded. Total Cost and Payback Period are the only ones given consideration at Air Staff, and therefore were considered the only necessities of this category (17:14 May 92; 30:14 May 92). Obligation Rate is

an indicator of the effectiveness of a base's financial management. This factor and whether the base is ready to execute the project are information desired by the MAJCOM for funding distribution. All other criteria under Financial Considerations were considered either redundant or noncontributory.

The six criteria under Political Sensitivity were combined to form two new criteria: Local Attention and National Attention. AFMC did not feel six separate criteria were necessary to address this area of emphasis. In merging these criteria, the three previous scores were averaged. The actual numeric averages (1.00 through 10.00) were entered into the computerized spreadsheet in an effort to capture the original scores given by the environmental managers at the bases.

Finally, the category entitled Other was scaled down to Safety Risk, Health Risk, Contribution to Environment, and Base Priority. Remaining criteria under this heading were also considered redundant or noncontributory.

AFMC Priorities. Once the Pollution Prevention Chief and his assistant finalized the criteria for use in DART, they were asked to prioritize the fifteen projects using their former methods. At that point, they worked independently to prioritize the projects from all three bases. Both managers, however, had different ideas as to which projects were most important and why.

The Chief based his priorities on the following assumptions:

1. Projects involving OLDS should be top priority, and
2. Projects with a payback of 3 years or less should be second priority (17:14 May 92).

The assistant used these assumptions:

1. Projects determining a baseline for the quantity of hazardous materials used or generated were top priority,
2. Projects involving OLDS were second priority, and
3. Projects with a payback of 3 or less years were third priority (30:14 May 92).

The results of the two decision makers' priorities are shown in Table 4-4.

Criteria Weighting. At this point, one element of information was still required before DART could be used to generate priorities -- criteria weighting factors. In determining the weights to apply to the various criteria, decision makers normally have goals and objectives in mind. For example, if decision makers want to ensure that projects having a significant contribution to the environment are funded, they would weight that criteria heavily. Weights applied in DART, therefore, are intended to reflect these types of objectives.

Due to the use of DIM equations, entropy also affects the level of emphasis given to criteria. The initial weights, therefore, served as starting points. Together, the two decision makers for AFMC determined weights for the original run of the DART model. Table 4-5 shows the weights used by DART, and a complete printout of the results are provided at Appendix J.

Table 4-4

AFMC Priorities

Project Title	Chief's Priorities	Assistant's Priorities
Phaseout of Ozone Depleting Chemicals	1	3
Freon Recovery, Recycling and Storage Equipment	2	4
Replace Refrigeration Purge Units	3	5
Pollution Prevention Opportunity Assessment	4	2
Baseline Pollution Prevention Audits	5	1
Repelletize/Reuse Spent Plastic Media Beads	6	10
Waste Oil Boiler	7	9
Waste Recycle Equipment	8	8
Electronic Imaging System	9	11
Waterfall Desludging Units	10	7
Supercritical Fluid Cleaning	11	6
Photopyrolysis Depaint System	12	12
Aircraft Corrosion Control Recycle Equipment	13	13
Off-Base Jet Noise Abatement	14	14
Needleless Intravenous System	15	15

(17:14 May 92; 30:14 May 92)

Table 4-5

Initial Weights

Category	Criteria	Weights Within Category	Overall 1st Iteration Weights
Financial Considerations 40%	Total Cost	20%	8%
	Payback Period	40%	16%
	Obligation Rate	10%	4%
	Ready to Execute	30%	12%
Political Considerations 40%	Local Attention	50%	20%
	National Attention	50%	20%
Other 20%	Safety Risk	15%	3%
	Health Risk	15%	3%
	Environmental Contribution	15%	3%
	Base Priority	55%	11%

(17:14 May 92; 30:14 May 92)

Table 4-5 also depicts three categories into which the criteria were divided: Financial Considerations, Political Considerations, and Other. Percentages were applied to each category to reflect the initial level of emphasis desired by the decision makers. Financial and Political Considerations both received 40%, and Other

received 20%. Within the three categories, percentages were applied to each of their criteria. The overall weight shown in Table 4-5 was determined by multiplying the category percentage by the criterion percentage. For example, under Overall 1st Iteration Weights, the overall weight for Total Cost was determined by multiplying the Financial Considerations percentage, 40%, by the weight given to Total Cost within this grouping, 20%. The resulting product was 8%. This method of grouping criteria allowed decision makers to add weight to entire categories more easily. This also simplified the process of ensuring that weights summed to 100%.

Analysis of DART

One of the distinctive characteristics of DART is that the importance of a single criterion is not determined by its assigned weight alone. Assigned weights are only a starting point and are adjusted after comparing DART's priorities with those of the decision maker. In the following segments, successive iterations of weighting schemes are used to rank the fifteen projects. Each iteration is analyzed by comparing DART's priorities with AFMC's. The purpose of this evaluation is to find a weighting scheme for DART which accurately reflects AFMC's objectives.

Initial Iterations and Analysis. In comparing the priorities generated by DART with those of the decision makers, Table 4-6 shows that first iteration weights did not reflect AFMC objectives. Four of the Chief's top five projects were scored as priority 10 or lower by DART. Although not identical, the top five priorities of the

Table 4-6

AFMC and Initial DART Priorities

Project Title	Chief's Priorities	Assistant's Priorities	DART's Priorities
Phaseout of Ozone Depleting Chemicals	1	3	15
Freon Recovery, Recycling and Storage Equipment	2	4	10
Replace Refrigeration Purge Units	3	5	11
Pollution Prevention Assessment Opportunity	4	2	1
Baseline Pollution Prevention Audits	5	1	12
Repelletize/Reuse Spent Plastic Media Beads	6	10	4
Waste Oil Boiler	7	9	3
Waste Recycle Equipment	8	8	2
Electronic Imaging System	9	11	7
Waterfall Desludging Units	10	7	5
Supercritical Fluid Cleaning	11	6	14
Photopyrolysis Depaint System	12	12	6
Aircraft Corrosion Control Recycle Equipment	13	13	8
Off-Base Jet Noise Abatement	14	14	13
Needleless Intravenous System	15	15	9

(17:14 May 92; 30:14 May 92)

Chief and his assistant were in general agreement. However, because of the disparity between DART and the two decision makers, a subsequent weighting scheme was attempted.

To identify criteria which required an increase or decrease in weight, project data were analyzed. A cursory look at the four Financial Considerations pointed out potential improvements in the weighting scheme. Total Cost data and Payback Period values for each of the fifteen projects are shown in Table 4-7. Analysis of this data showed that these criteria may have been weighted too heavily. High cost projects with high payback periods, such as Phaseout of Ozone Depleting Chemicals, were given low priority while lower cost projects with low payback periods gravitated to the top of DART's priorities. In addition, for the criteria of Obligation Rate and Ready to Execute, all fifteen projects had identical values (see Appendix J). Obligation Rate values were all 1.00, and Ready to Execute values were 10.00. In other words, all projects in both criteria achieved the ideal scores. Mathematically, this meant these criteria were not contributing to the final decision regarding priorities.

Based on these observations, the decision makers reduced the weight applied to Financial Considerations and increased the weight of Political Considerations. Total Cost and Payback Period were both reduced to 0.5%; Obligation Rate and Ready to Execute were given no weight (0%). Table 4-8 shows the adjusted (second

Table 4-7

Summary of Selected Financial Criteria

Project Title	DART's Priority	Total Cost ($1000s)	Payback Period (yrs)
Pollution Prevention Assessment Opportunity	1	304	0.72
Waste Recycle Equipment	2	190	1.90
Waste Oil Boiler	3	296	1.60
Repelletize/Reuse Spent Plastic Media Beads	4	250	3.10
Waterfall Desludging Units	5	60	5.50
Photopyrolysis Depaint System	6	1100	5.00
Electronic Imaging System	7	1400	3.40
Aircraft Corrosion Control Recycle Equipment	8	1475	15.50
Needleless Intravenous System	9	83	30.00
Freon Recovery, Recycling and Storage Equipment	10	150	30.00
Replace Refrigeration Purge Units	11	150	30.00
Pollution Prevention Assessment Opportunity	12	1000	30.00
Off-Base Jet Noise Abatement	13	1000	30.00
Supercritical Fluid Cleaning	14	2700	18.00
Phaseout of Ozone Depleting Chemicals	15	3895	30.00

(17:14 May 92; 30:14 May 92)

iteration) weights, and Table 4-9 shows the new priorities generated by DART.

Second iteration figures shown in the tables below were taken from Appendix K.

Table 4-8

Second Iteration Weights

Category	Criteria	1st Iteration Weights	2nd Iteration Weights
Financial Considerations	Total Cost	8%	0.5%
	Payback Period	16%	0.5%
	* Obligation Rate	4%	0%
	* Ready to Execute	12%	0%
Political Considerations	Local Attention	20%	30%
	National Attention	20%	30%
Other	Safety Risk	3%	3%
	Health Risk	3%	3%
	Environmental Contribution	3%	3%
	Base Priority	11%	30%

* All projects received identical scores in these criteria.

Table 4-9

Second Iteration Priorities

Project Title	Chief's Priorities	Assistant's Priorities	DART's 1st Iteration Priorities	DART's 2nd Iteration Priorities
Phaseout of Ozone Depleting Chemicals	1	3	15	13
Freon Recovery, Recycling and Storage Equipment	2	4	10	3
Replace Refrigeration Purge Units	3	5	11	7
Pollution Prevention Assessment Opportunity	4	2	1	1
Baseline Pollution Prevention Audits	5	1	12	5
Repelletize/Reuse Spent Plastic Media Beads	6	10	4	2
Waste Oil Boiler	7	9	3	4
Waste Recycle Equipment	8	8	2	8
Electronic Imaging System	9	11	7	12
Waterfall Desludging Units	10	7	5	6
Supercritical Fluid Cleaning	11	6	14	14
Photopyrolysis Depaint System	12	12	6	11
Aircraft Corrosion Control Recycle Equipment	13	13	8	9
Off-Base Jet Noise Abatement	14	14	13	15
Needleless Intravenous System	15	15	9	10

(17:14 May 92; 30:14 May 92)

The changes made in the second weighting scheme brought DART's priorities somewhat more in line with those of the AFMC managers. However, projects such as Phaseout of Ozone Depleting Chemicals and Supercritical Fluid Cleaning were ranked significantly lower than desired, and Repelletize/Reuse Spent Plastic Media Beads and Waste Oil Boiler were ranked too high. In an effort to determine if Total Cost and Payback were still the cause of DART's conflicting priorities, the weights applied to all Financial Consideration criteria were changed to zero. In effect, this action eliminated the influence of these criteria altogether. The new weighting scheme and resulting priorities are shown in Tables 4-10 and 4-11. Actual data for the third iteration are shown in Appendix L.

DART's third iteration priorities were not only closer to those of AFMC's, but the Phaseout of Ozone Depleting Chemicals climbed from priority thirteen to priority number one. Also, Waste Oil Boiler dropped to a more agreeable position by falling from priority four to nine. In fact, DART's top six priorities were merely a different combination of the Chief's. However, there were still problems. For example, DART was still ranking Waste Recycle Equipment and Electronic Imaging System too low.

Modifications. Following the initial iterations, two types of modifications were made to DART. The first change addressed the problem of dominant criteria,

Table 4-10

Third Iteration Weights

Category	Criteria	2nd Iteration Weights	3rd Iteration Weights
Financial Considerations	Total Cost	0.5%	0%
	Payback Period	0.5%	0%
	Obligation Rate	0%	0%
	Ready to Execute	0%	0%
Political Considerations	Local Attention	30%	27%
	National Attention	30%	27%
Other	Safety Risk	3%	10%
	Health Risk	3%	3%
	Environmental Contribution	3%	3%
	Base Priority	30%	30%

while the other changes enhanced existing features by calculating criteria weights differently, and incorporating new data for one criterion.

Dominant Criteria. In each of the previous iterations, financial criteria were the focus of attention. The decision makers for AFMC wanted to consider these, but the prioritized list that came the closest to meeting AFMC's

Table 4-11

Third Iteration Priorities

Project Title	Chief's Priorities	DART's 1st Iteration Priorities	DART's 2nd Iteration Priorities	DART's 3rd Iteration Priorities
Phaseout of Ozone Depleting Chemicals	1	15	13	1
Freon Recovery, Recycling and Storage Equipment	2	10	3	4
Replace Refrigeration Purge Units	3	11	7	6
Pollution Prevention Assessment Opportunity	4	1	1	3
Baseline Pollution Prevention Audits	5	12	5	2
Repelletize/Reuse Spent Plastic Media Beads	6	4	2	5
Waste Oil Boiler	7	3	4	9
Waste Recycle Equipment	8	2	8	15
Electronic Imaging System	9	7	12	13
Waterfall Desludging Units	10	5	6	11
Supercritical Fluid Cleaning	11	14	14	8
Photopyrolysis Depaint System	12	6	11	14
Aircraft Corrosion Control Recycle Equipment	13	8	9	7
Off-Base Jet Noise Abatement	14	13	15	12
Needleless Intravenous System	15	9	10	10

(17:14 May 92; 30:14 May 92)

objectives gave these factors a weight of zero. When DART did consider these criteria, Financial Considerations had a dominating influence. Therefore, a method of incorporating financial criteria without their dominating influence was required.

To include Financial Considerations without allowing it to dominate, was to thoroughly review data from the first iteration weighting scheme. This reassessment of data revealed that entropy was at the heart of the problem. As shown in Table 4-12, the e(d) values for Total Cost and Payback Period were lower than for any other criterion. (Recall that a lower e(d) value implies greater entropy.)

Table 4-12

Analysis of Entropy

Criteria	Entropy, e(d) (Appendix J)
Total Cost	0.7973
Payback Period	0.8616
Obligation Rate	1.0000
Ready to Execute	1.0000
Local Attention	0.9692
National Attention	0.9523
Safety Risk	0.9335
Health Risk	0.9357
Environmental Contribution	0.9895
Base Priority	0.9558

This added significant emphasis to the final priorities. While the entropy values for Total Cost and Payback Period were 0.7973 and 0.8616, respectively, all other entropy values were greater than 0.93. Zeleny states that the criteria with the greatest entropy has the greatest impact on the final prioritization (38:189). This explains the dominant impact Total Cost and Payback Period were having on the priorities generated by DART.

Once this difficulty was recognized, a method of incorporating Total Cost and Payback Period could be devised to decrease their entropy. In order to do this, a system was needed to reduce the spread of data in the original data table. This was accomplished by grouping Total Costs and Payback Periods as shown in Tables 4-13 and 4-14.

Table 4-13

Restructuring of Total Cost Data

Total Cost (x)	Points
$x \leq \$15,000$	4
$\$15,000 < x \leq \$100,000$	3
$\$100,000 < x \leq \$300,000$	2
$x > \$300,000$	1

Table 4-14

Restructuring of Payback Period Data

Payback Period (x)	Points
$x \leq 1$ Year	5
1 Year $< x \leq 3$ Years	4
Research or Study	3
3 Years $< x \leq 5$ Years	2
$x > 5$ Years	1

These revised Total Cost and Payback Period data were then entered into DART with the original weighting scheme. Appendix M shows the revised data entered into the original data matrix.

Enhancements. The only other changes made were the addition of base obligation rates data and a system to assign weights to the individual criteria. Obligation rates were not available until this point in the data collection process. Appendix M shows that under the criterion of Obligation Rate, McClellan projects were given a score of 0.67 points indicating that McClellan had obligated 67% of its funds at that point in time. Wright Patterson AFB projects received a score of .70, and Hill projects received 0.63 points.

Regarding the new weighting system, rather than assign percentages to each criterion and check to ensure they summed to 100%, a point system was devised. In

this system, points were assigned to each criterion and a sum was calculated for the total points. The computerized spreadsheet calculated both the sum of all the points and the percentages automatically. In the previous system, if the percentage applied to one criterion was increased by the decision maker, he or she would have to subtract an equal percentage from other criteria. Using a point system, it was possible to add points to one criterion without having to subtract from others. The percentages for all criteria were calculated automatically.

Final Iterations and Analysis. When modifications and enhancements were made, the revised data were entered into DART. Points and weights assigned to the criteria are shown in Table 4-15. For the purpose of comparison, the new entropy values are shown in Table 4-16. Notice that entropy values for all criteria have a smaller spread. Total Cost and Payback Period are no longer given the additional emphasis due to entropy. The resulting prioritized list is shown in Table 4-17.

Table 4-17 shows that all but two projects were ranked within three points of the Chief's priorities: Waterfall Desludging Units and Needleless Intravenous System. It was at this point that both decision makers stated that DART adequately reflected their goals (17:14 May 92; 30:14 May 92).

Strategies. The next two iterations of DART were performed to try different weighting strategies. The first attempted strategy added emphasis to Payback Period, a recent area of focus by Air Staff (17:14 May 92). Table 4-18 shows points

Table 4-15

Assigning Weights from Points

Category	Criteria	1st Iteration Points	1st Iteration Weights
Financial Considerations	Total Cost	8	.0800
	Payback Period	16	.1600
	Obligation Rate	4	.0400
	Ready to Execute	12	.1200
Political Considerations	Local Attention	20	.2000
	National Attention	20	.2000
Other	Safety Risk	3	.0300
	Health Risk	3	.0300
	Environmental Contribution	3	.0300
	Base Priority	11	.1100

assigned to Payback Period were increased to 50. The final iteration emphasized Political Considerations by increasing Local and National Attention to 50 points, and lessening the impact of Payback Period by decreasing its points to 25. The affect both of these weighting strategies had on priorities is shown in Table 4-19. Adjusted

Table 4-16

Revised Entropy Values

Criteria	Original Entropy, e(d) (Appendix J)	Revised Entropy, e(d) (Appendix M)
Total Cost	0.7973	0.9642
Payback Period	0.8616	0.9359
Obligation Rate	1.0000	0.9997
Ready to Execute	1.0000	1.0000
Local Attention	0.9692	0.9692
National Attention	0.9523	0.9523
Safety Risk	0.9335	0.9335
Health Risk	0.9357	0.9357
Environmental Contribution	0.9895	0.9895
Base Priority	0.9558	0.9558

criteria weights and the new priorities for the second iteration are shown in Appendix N, and third iteration weights and priorities are at Appendix O.

In comparing the Chief's priorities to those shown in the second and third iterations, five or more projects in each iteration were four or more points away. Evaluation of the changes in project rankings showed that the different weighting strategies could have been anticipated. The most significant movement in project ranking is noticed in the Waste Recycle Equipment project. This project had a good payback period (Appendix M), and when emphasis was added to this criterion,

Table 4-17

Revised First Iteration Priorities

Project Title	Chief's Priorities	DART's Priorities
Phaseout of Ozone Depleting Chemicals	1	2
Freon Recovery, Recycling and Storage Equipment	2	5
Replace Refrigeration Purge Units	3	6
Pollution Prevention Assessment Opportunity	4	1
Baseline Pollution Prevention Audits	5	3
Repelletize/Reuse Spent Plastic Media Beads	6	4
Waste Oil Boiler	7	7
Waste Recycle Equipment	8	11
Electronic Imaging System	9	12
Waterfall Desludging Units	10	14
Supercritical Fluid Cleaning	11	8
Photopyrolysis Depaint System	12	15
Aircraft Corrosion Control Recycle Equipment	13	10
Off-Base Jet Noise Abatement	14	13
Needleless Intravenous System	15	9

(17:14 May 92; 30:14 May 92)

Table 4-18

Revised Second and Third Iteration Points/Weights

Category	Criteria	1st Iteration Points	2nd Iteration Points	3rd Iteration Points
Financial Considerations	Total Cost	8	8	8
	Payback Period	16	50	25
	Obligation Rate	4	4	4
	Ready to Execute	12	12	12
Political Considerations	Local Attention	20	20	50
	National Attention	20	20	50
Other	Safety Risk	3	3	3
	Health Risk	3	3	3
	Environmental Contribution	3	3	3
	Base Priority	11	11	11

Waste Recycle Equipment jumped in rank from number eleven to number six. However, in changing emphasis from Payback Period to Political Attention in the third iteration, Waste Recycle Equipment dropped from priority six to fourteen. Repelletize/Reuse Spent Plastic Media Beads and Waste Oil Boiler also fell in the third iteration ranking. This is explained by the poor scores these projects received

Table 4-19

Revised Second and Third Iteration Priorities

Project Title	Chief's Priorities	DART's 1st Iteration Priorities	DART's 2nd Iteration Priorities	DART's 3rd Iteration Priorities
Phaseout of Ozone Depleting Chemicals	1	2	5	2
Freon Recovery, Recycling and Storage Equipment	2	5	7	4
Replace Refrigeration Purge Units	3	6	8	5
Pollution Prevention Assessment Opportunity	4	1	1	1
Baseline Pollution Prevention Audits	5	3	3	3
Repelletize/Reuse Spent Plastic Media Beads	6	4	2	6
Waste Oil Boiler	7	7	4	9
Waste Recycle Equipment	8	11	6	14
Electronic Imaging System	9	12	10	11
Waterfall Desludging Units	10	14	15	15
Supercritical Fluid Cleaning	11	8	9	7
Photopyrolysis Depaint System	12	15	12	12
Aircraft Corrosion Control Recycle Equipment	13	10	13	13
Off-Base Jet Noise Abatement	14	13	14	10
Needleless Intravenous System	15	9	11	8

in Local and National Attention. When weight was added to these criterion, the distance of these projects from the ideal was increased. Off-Base Jet Noise, on the other hand, benefited from the added emphasis placed on Local and National Attention. Jet noise around near Air Force bases is a recognized problem and is receiving increased attention. The impact of adding weight to Local and National Attention raised the Off-Base Jet Noise project from fourteen to ten.

Findings

Despite the agreeable results of DART, some projects were still ranked either too high or too low in comparison to the decision makers' desires. Because of this, decision makers stated they would override priorities determined by DART if they felt a certain project better met the interests of the Air Force. This can be explained with an example. In the first iteration of priorities in the revised version of DART (Table 4-19), the Chief's number three priority was Replace Refrigeration Purge Units. If AFMC only had enough money to fund three projects, this project would be one of them, despite the fact DART ranked it number six. On the other hand, if AFMC only had enough money to fund nine projects, they would not fund Needleless Intravenous System, ranked number nine by DART, since they felt it should have been number fifteen. For the most part, however, the majority of pollution prevention projects were ranked according to their preferences (17:17 May 92).

DART's ability to recognize different weighting strategies was also important. When weights were changed to add or diminish emphasis to certain criteria, DART generated revised priorities. A potential for time savings is evident. In addition, simple experimentation allows decision makers to see how changes in strategy would impact funding decisions.

Another significant finding was that, although decision makers have preferences for certain alternatives, DART is able to incorporate the majority of these preferences. In using DART, decision makers are forced to identify their true preferences when they select criteria and their appropriate weights. This identification process allows them to communicate these preferences to other environmental managers. Therefore, DART is particularly useful in communicating decision maker preferences to subordinates.

Conclusion

The intent of this research was to provide a management tool to assist AFMC decision makers in ranking pollution prevention projects. In developing such a tool, certain requirements had to be met. The tool required the ability to incorporate various types of data and criteria, the ability to provide flexibility and maintainability, and the capacity to manipulate large volumes of data in minimal time.

DART successfully incorporated objective and subjective data, and independent and dependent criteria. Data for Total Cost was independent and objective, and Payback Period data was dependent and objective. National Attention and Environmental Contribution were both examples of subjective data. Flexibility and maintainability were exhibited when modifications were made to DART regarding criteria and weighting modifications. The fact that any number or combination of criteria may be used also attests to its flexibility. In addition, the decision makers were given the ability to experiment with different weighting strategies and scoring systems. Updates, such as those performed on the Obligation Rate, confirmed DART's ease of maintainability. Finally, DART not only enhanced flexibility and maintainability through the use of computer technology, but it gave the decision maker the potential to handle a large volume of data.

V. Summary, Conclusions, and Recommendations

Overview

The purpose of this research was to develop a tool to assist decision makers with the allocation of limited funds. DART was developed specifically for AFMC decision makers to rank pollution prevention projects as a means of identifying the projects to be funded. This chapter states how this objective was accomplished. Conclusions are then drawn based upon research findings, and this is followed by a discussion of contributions and insights. Finally, recommendations are given for further research.

Summary

To develop a model to rank pollution prevention projects, a review of the standard methods in Multiple Criteria Decision Models was performed. In researching the common techniques used in these models, the Displaced Ideal Model (DIM) was determined to best meet established needs of AFMC decision makers. Further review of Air Force methods used to rank alternatives proved that the DIM had been successful in this area. A model was then developed by incorporating the DIM equations into a computerized spreadsheet.

To implement the DIM Alternative Ranking Technique (DART), appropriate criteria were selected by environmental experts, and finalized by the decision makers at AFMC. Data was then collected and incorporated into the spreadsheet containing the DIM equations. Finally, the decision makers selected weights for the criteria which they felt reflected environmental objectives of the MAJCOM. At this stage, analysis and refinement of DART began.

To determine if DART met the expectations of the decision makers at AFMC, three different weightings of the criteria were implemented and compared to the prioritized lists of the decision makers. When none of the priorities matched, analysis revealed that two criteria were dominating the prioritization. This was resolved by revising the grading scales. The original weights were then reapplied with the adjusted scores, and this time DART satisfied the decision makers' requirements. Different strategies were tested successfully when priorities changed according to the emphasis added to certain criteria.

Conclusions

Overall, DART met the objectives of this research and the expectations of AFMC. It is an effective decision making tool for decision makers to rank pollution prevention projects, and it allows decision makers to incorporate their management strategies so that their objectives can be met. It handles the various types of data

and criteria required, and is flexible and easy to maintain. In addition, it has the potential to handle any number of projects evaluated in any number of criteria.

Contributions

Once a strategy is incorporated into the model, DART measures each project equally. This fair judgment gives the decision maker the ability to distribute funds equitably. In addition, it is possible for these strategies to be communicated to base level managers when requests for data are made. Criteria must be identified by the decision maker in order to collect the necessary data from base level managers. This, in turn, allows bases to better manage their own programs.

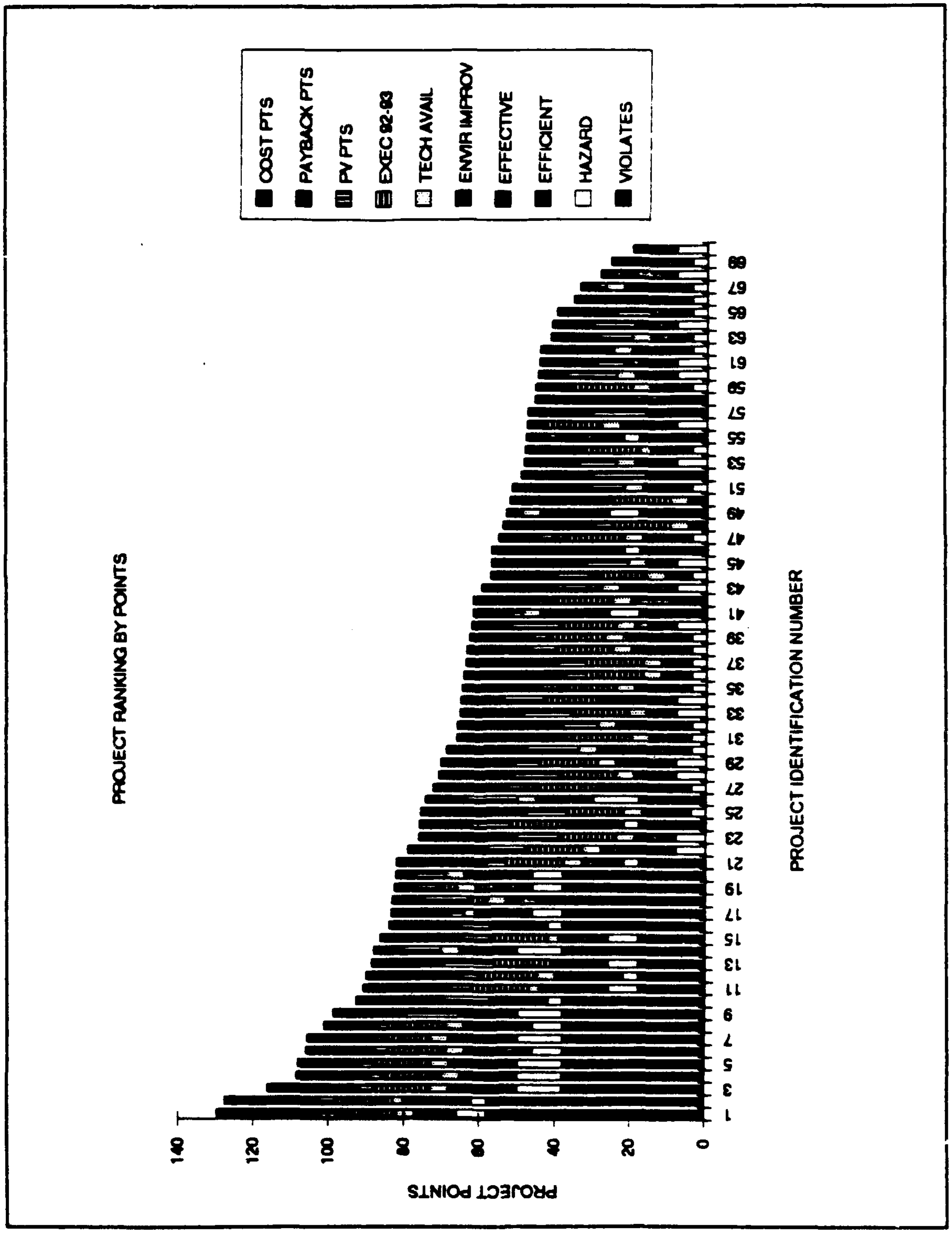
Insights

DART is an effective tool for establishing priorities which reflect decision maker objectives. Refinement of DART, however, requires careful analysis and thought. Decision makers vary widely in the way they set priorities, and it is difficult to capture their different assumptions and instincts. This may prevent DART from realizing its full potential. Decision makers may override some of DART's priorities because of disagreement. However, if a decision maker continues to refine this tool, the potential benefits of DART increase, and there is less likelihood of disagreement between the DART and the decision maker. Added refinement also enhances communication of objectives to base level managers.

Recommendations

Three recommendations are offered for study related to this research. First, DART may be further refined so that it better simulates AFMC decision maker objectives. Second, it may be tested in different MAJCOMs, where it should not necessarily be limited solely to ranking pollution prevention projects. Level I and Level II projects are likely candidates for application of DART. Finally, any field of management requiring priorities to be established may adapt DART as an aid to the decision making process.

Appendix A: Chart from McClellan AFB Decision Model



Appendix B: List of USAF Environmental Managers

Secretary of the Air Force	Office Symbol
Lt Col Fink	SAF/MIQ
Air Staff	
Capt Ahern	HQ USAF/LEEVO
Air Force Center for Environmental Excellence	
Capt Briesmaster	AFCEE/ESEM
Major Command	
Maj Decker	HQ ACC/DEV
Capt Mann	HQ AMC/LEVC
Capt Meadows	HQ PACAF/DEVC
Lt Nester	HQ ATC/DEV
Mr Byrne	HQ AFSPACECOM/CEVC
Mr Coughman	HQ AMC/LEVC
Mr Fujimoto	HQ PACAF/DEV
Ms Murdock	HQ AFMC/CEVZ
Mr Vickers	HQ ATC/DEV
Base Level	
Mr Rockswold	SM-ALC/EMPM
Ms Wilhelm	2750 ABW/EMX
Other	
Lt Col Solomon	University of North Carolina

Appendix C: Letter and Attachments Sent to USAF Managers

From: Capt Scott McPherson and Capt Debra Watts (DSN 785-2155)

Subject: Prioritizing Pollution Prevention Projects for Funding

To: (Office Symbol)

1. The list of "attributes" that I mentioned in our recent telephone conversation is attached for your review (Atch 1). These are the items identified so far which may be considered when prioritizing pollution prevention projects. If you can think of something to add, we would be very interested in including it in our research. This same list is being sent to all other MAJCOMs, the AFCEE, the SAF/MIQ office, and Air Staff. Comments from all sources will be compiled and we will then forward a second, more complete list of attributes to you to see if more ideas can be generated. At that time, we will ask you to choose the ten attributes you believe to be the most important to consider when evaluating pollution prevention projects for funding.

2. Our second request is data for FY 91, FY 92, and your best estimate for FY 93 in the following areas, if applicable:

- the total number of pollution prevention projects identified by bases in your MAJCOM
- the funds requested to perform them, and
- the funds actually distributed for these projects

Attachment 2 shows a sample format which should clarify the type of information we need. An abstract of our thesis is also provided (Atch 3) and we will gladly forward a copy of the final product to you if you are interested.

3. Your assistance and input is very much appreciated. If you have any questions at all, please don't hesitate to contact either of us at AFIT/DEVG, Wright-Patterson AFB OH 45433, DSN 785-2155, Commercial (513) 255-2155. Please FAX your response to us by 10 April at 785-5188. Thank you again for your participation in our research.

SCOTT W. McPHERSON, Capt, USAF
Graduate Student
AFIT Engr & Env Mgt Master's Program

3 Attachments
1. Attribute List
2. MAJCOM Data Request Form
3. Thesis Abstract

ATTRIBUTES

Financial Considerations:
Total Cost
Payback Period
Return on Investment (if available/applicable)

Political Sensitivity of Project:
* Attention from Regulators (Federal, State, Local)
* Attention from Public (Local, National)
* Attention from MAJCOM Department of Defense Leaders
* Attention from Local Department of Defense Leaders
* Attention from Air Staff

Other:
* Safety Risk/Benefit
* Health Risk/Benefit
* Contribution to/Enhancement of Environment
Base Priority

Comments/Additions:

* Qualitative Criteria

Atch 1

Appendix C (continued): Letter and Attachments Sent to USAF Managers

MAJCOM USE ONLY:

This table is provided to clarify the data requested from your MAJCOM. Please provide the most accurate data available for FY 91 and FY 92. Your best estimate for FY 93 is also requested. If additional clarification is needed, please don't hesitate to contact either of us.

Pollution Prevention Project Information	FY 91	FY 92	FY 93 (Estimate)
Total Number Identified			
Total Funds Requested			
Total Funds Distributed			

Atch 2

ABSTRACT

Prioritizing Pollution Prevention
Projects for Funding

Dean T. Kashiwagi, PE, PhD, Major, USAF
Scott W. McPherson, BS, Capt, USAF
Debra J. Watts, BS, Capt, USAF

The authors have developed a method to prioritize pollution prevention projects for the distribution of limited funding resources. The method is designed for use at the major command (MAJCOM) level. Each MAJCOM would be allowed to select the attributes believed to be most appropriate for evaluating pollution prevention projects. The system also allows the flexibility for MAJCOMs to weight the attributes in accordance with requirements. The methodology uses "fuzzy logic" and the "Displaced Ideal" model (DIM) to prioritize projects which currently do not have an imminent compliance deadline, but are important due to potential noncompliance with future regulations. These projects are also important because their completion demonstrates a commitment to good management practices which make better use of resources and otherwise enhance the environment. The methodology uses the "amount of information" given by the data to integrate and compare qualitative and quantitative criteria. The prioritization includes considering factors such as total project cost, health and safety considerations, and political sensitivity. The methodology can also be used to prioritize projects that are currently out of compliance (Level I) or projects which must meet an established deadline before it lapses into noncompliance (Level II).

Atch 3

Appendix D: Original List of Criteria for AFMC Bases

ATTRIBUTES

Financial Considerations:

Total Cost (dollars)
Net Present Value (if available/applicable) (dollars)
Payback Period (if available/applicable) (years)
Obligation Rate of Requesting Base (Spending Record) (MAJCOM use only) (percentage)
Ready to execute or not (ready to advertise) (yes/no)
Return on Investment (if available/applicable) (percentage)
Savings generated (Lifetime) (if available/applicable) (dollars)
Equitable distribution of funds to bases in command? (MAJCOM use only) (yes/no)
Equitable distribution of funds to environmental programs? (MAJCOM use only) (yes/no)

Political Sensitivity of Project (Score on a scale from a low of 1 to a high of 10):

* Attention from Regulators (Federal, State, Local)
* Attention from Public (Local, National)
* Attention from Congressional Sources (Federal, State)
* Attention from MAJCOM Department of Defense Leaders
* Attention from Local Department of Defense Leaders
* Attention from Air Staff

Other:

* Safety Risk/Benefit (Lo=0, Med=5, Hi=10)
* Health Risk/Benefit (Lo=10, Med=5, Hi=10)
* Contribution to/Enhancement of Environment (Lo=0, Med=5, Hi=10)
  Base Priority (Actual Priority Number AND Total Number of Class III Projects)
* Potential for meeting future requirement/law/regulation (Lo=0, Med=5, Hi=10)
  Is technology available? (yes/no)
* Public Relations Contribution (Lo=0, Med=5, Hi=10)

Comments/Additions:

* Qualitative Criteria

Appendix E: AFMC Pollution Prevention Projects

Pollution Prevention Projects to be Prioritized

Project #	Description
Wright-Patterson AFB (WP-xxxxxx)	
xxxxxx	Baseline Pollution Prevention Audits
xxxxxx	Freon Recovery, Recycling and Storage Equipment
xxxxxx	Replace Refrigeration Purge Units
xxxxxx	Needleless Intravenous System
xxxxxx	Electronic Imaging System
McClellan AFB (SM-xxxxxx)	
931602	Repelletize/Reuse Spent Plastic Media Beads
921602	Aircraft Corrosion Control Recycle Equipment
981604	Supercritical Fluid Cleaning
921643	Waste Recycle Equipment
921610	Photopyrolysis Depaint System
Hill AFB (OO-xxxxxx)	
940727	Phaseout of Ozone Depleting Chemicals
920797	Pollution Prevention Opportunity Assessment
870172	Waste Oil Boiler
920743	Waterfall Desludging Units
960732	Off-Base Jet Noise Abatement

POLLUTION PREVENTION POM SUBMITTAL

Installation: Wright-Patterson Air Force Base

Project: Baseline Pollution Prevention Audits

FY: 92

Current Process: Approximately 600 laboratories and shops conduct various mission activities throughout WPAFB. These activities generate numerous waste streams of all types. There is no coordinated effort to identify, quantify, and reduce waste generation.

New Process: Conduct baseline pollution prevention audits of the laboratories and shops. This effort will also recommend pollution prevention projects for implementation to reduce waste.

Environmental Benefits: Reduced volume of waste for disposal. Reduced potential for long-term liability associated with off-base disposal. Reduced personnel exposure to hazardous waste.

Economics: Reduced waste disposal costs. Potentially lower operating costs for the laboratories and shops. Not definable at this time.

Fund Appropriation: $ 500,000/ 3400

Stock Class: N/A

TSFZP2

Date: 12 Apr 92

Installation: Wright-Patterson AFB

Project Priority: 1

Project Title: Freon Recovery, Recycling and Storage Equipment

Description of Project: Purchase equipment for removing refrigerants from systems, storing recovered refrigerants, and removing oils and acids from recovered refrigerants.

Funding ($K): 125.0 - FY92

Type of OLDS being Eliminated: NA

Quantity of OLDS Usage to be Eliminated: NA

Estimated Quantity of OLDS Releases to be Eliminated: 10,000 lbs/yr

Substitute Chemical/Product to be Used: NA

Status of Testing/Approvals (if required) for new Product/Process: Equipment is commercially available

Status of any Acquisition Approvals/Processing: NA

Estimated Contract Award (ie Funds Obligation) Date: Immediately upon receipt of funding.

Estimated Completion/Operational Date: 30 days after receipt of funding.

Impacts if not Funded: In the event that the refrigeration equipment requires servicing by removing the refrigerant or to refrigerant becomes contaminated with acids or oil, service personnel will be required to release refrigerant in violation of CAA to repair equipment.

POC/Organization/Symbol/Phone#: Ed Hess/2750 ABW/EME/257-5535

TSFZP1

Date: 12 Apr 92

Installation: Wright-Patterson AFB

Project Priority: 1

Project Title: Replace Refrigeration Purge Units

Description of Project: Purge units on R-11 units remove atmospheric gases that infiltrate the refrigeration system. All of the units installed on WPAFB R-11 refrigeration equipment are older models that lose approximately 10 pounds of Freon for every pound of air purged. New purge units lose approximately 1 pound of Freon per pound of air.

Funding ($K): 150.0 - FY92

Type of OLDS being Eliminated: None

Quantity of OLDS Usage to be Eliminated: None

Estimated Quantity of OLDS Releases to be Eliminated: 5,000 lbs/yr

Substitute Chemical/Product to be Used: NA

Status of Testing/Approvals (if required) for new Product/Process: High efficiency purge units are commercially available.

Status of any Acquisition Approvals/Processing: NA

Estimated Contract Award (ie Funds Obligation) Date: Immediate on receipt of funding.

Estimated Completion/Operational Date: 60 days after receipt of funding.

Impacts if not Funded: Refrigerant will be lost at a rate that can not be compensated for by salvaging refrigerants from scraping old units. This will result in premature loss of the utility of R-11 systems at an approximate cost of $18 M.

POC/Organization/Symbol/Phone#: Ed Hess/2750 ABW/EME/257-5535

POLLUTION PREVENTION POM SUBMITTAL

Installation: Wright-Patterson Air Force Base

Project: Needleless Intravenous (IV) System, USAF Medical Center

FY: 92

Current Process: The base Medical Center uses a standard syringe needle system for intravenous (IV) injections and inoculations. The used syringe needles are handled as infectious waste and are dangerous to hospital and janitorial personnel in terms of the potential for accidental sticks with contaminated needles.

New Process: The new system will employ a needleless kit for IV injections to eliminate the potential for sticks during this procedure. For other injection procedures, the system uses syringes that are modified with a protective sheath. This sheath is slid over the needle after use and is locked in place, thus eliminating the potential for sticks while handling. This new system is being used in five of seven area hospitals and the frequency of accidental sticks has been reduced by over 80%.

Environmental Benefits: Currently handlers of biohazard red bag waste are periodically stuck by the existing exposed needles. Conversion to the new system will reduce the amount of needles and sharp containers currently being disposed of as infectious waste and will significantly reduce number of and potential for accidental sticks during waste handling operations.

Economics: Conversion to the needleless system will require an additional $83,000. The volume of infectious waste requiring disposal will be reduced. The new system will greatly reduce the potential for damaging litigation and increased health care costs due to the consequences of accidental sticks.

Fund Appropriation: 3400

Stock Class: N/A

Application to Others: Successful conversion to this new system at the command's largest hospital will demonstrate its applicability across the AFMC community.

POLLUTION PREVENTION POM SUBMITTAL

Installation: Wright-Patterson Air Force Base

Project: Electronic Imaging System, ASD/RMV

FY: 92

Current Process: The ASD/RMV Photography Laboratory, Building 20020, uses six conventional wet chemistry processes to provide various photographic support services for its customers. These processes require the use of fixers, developers, activators, replenishers and stabilizers. Most of these chemicals, along with process water, are discharged to the sanitary sewer after use, although some must be turned in as hazardous waste to the DRMO. These processes also require approximately 2,700,000 gallons of tempered water per year to operate.

New Process: A new process, called the Electronic Imaging System, has been developed commercially which precludes the use of wet chemistry processes. Photographic images are digitally stored on compact disks similar to files on a floppy disk. These images can be edited, merged to form new images, and restored at computer work stations quickly and easily. The new process would be implemented over a multi-year time period. Product quality is maintained. Process time and cost to the customer are significantly reduced.

Environmental Benefits: The acquisition, storage, use and disposal of wet chemicals is completely avoided. Worker exposure to potentially harmful chemicals is averted. Use and disposal of 2,700,000 gallons of tempered water per year is avoided.

Economics:	Cost of New System	FY92	$ 400,000
		FY93	$ 100,000
		FY94	$ 400,000
		FY95	$ 100,000
		FY96	$ 400,000
	Cost Savings	Chemicals	$ 283,000
		Maintenance	$ 20,000
		Utilities	$ 4,050
		Customer Savings (est)	$ 100,000
		Hazardous Waste Disposal (est)	$ 6,100
		Total Yearly Savings	$ 413,150
	Payback Period	3.4 years	

Fund Appropriation: 3080

Stock Class: N/A

A. McClellan AFB, CA

B. Installation Priority: ~~22~~ ~~23~~ ~~24~~ 26

C. Project Title: Repelletize/reuse spent plastic media beads

D. Project Number: PRJY 931602

E. FY:	92	94	95	96	97	98	99
F. Cost: $K, 3080							
	3400	200	200	50			

G. Current Process: Currently, plastic media are used in the blasting process until they are reduced to dust. The dust is collected and disposed as hazardous waste due to contained paint contaminants.

H. New Process: The spent beads will be collected, screened to remove extraneous material, melted in a heated screw device and formed into new reusable beads. Any remaining contaminants will be encapsulated into the new beads. New material can be added to modify characteristics of the finished beads, if desired. When the beads can no longer be recycled, because of contaminants, they can be remelted to encapsulate the contaminants and reformed into useful plastic objects e.g. cabinet cases, shelving, machinery covers, moldings, furniture parts, etc.

Project is to demonstrate feasibility of reforming and reusing beads, to evaluate the effects of contaminants on stripped surfaces and to evaluate alternate uses for the contaminated beads.

I. Environmental Benefits: Environmental benefits are reduction or elimination of a hazardous waste by turning it into a useful product. Purchase costs for new beads will be reduced and purchase costs for disposal drums will be eliminated.

J. Maintainability/Reliability Benefits: No impact is expected

K. Impact on Mission: No impact is expected.

L. Economics: Currently, $120K per year are spent to dispose of spent beads at McClellan AFB alone. This process, if adopted, would be exportable throughout DoD wherever thermoplastic media beads are used to remove old paint from surfaces. Payback at McClellan AFB is 30 months. In addition, it is possible that reformed beads or beads formed into useful products could be sold.

M. Federal Stock Number/Class:

N. A current copy of an A-106 has not been developed.

A. Installation: McClellan AFB, CA

B. Installation Priority: ~~23~~ ~~27~~ ~~28~~ ~~26~~ 27

C. Project Title: Acft Corr Cont Recycle Equip B692
(Paint Hangar Wastewater Recycling System)

D. Project Number: PRJY 921602

	Total	92	94	95	96	97	98	99
E. FY:		92	94	95	96	97	98	99
F. Cost: $K,	3080		125	650				
	3400	175	400	300				

G. Current Process: The acid wash/chromate conversion coating (alodine) process produces wastewater with residues of chromium and other hazardous materials. Wastewater is generated by the alodine process. The waste water drains to the industrial waste collection system ; however, the base has agreed to cease discharging hazardous waste through the collection system by mid-1993.

H. New Process: A system will be designed to treat wastewater from the acid/alodining process. This system will return water for reuse in the facility. After review and approval by the base, this system will be installed.

I. Environmental Benefits: Reduction in wastewater generation and fresh water consumption by 20,000 gallons/week.

J. Maintainability/Reliability Benefits:

K. Impact on Mission: Eliminates costs associated with collecting wastewater and transporting it to industrial waste treatment plant for disposal. Reduces resources (fresh water) needed to perform mission.

15.5 Y

L. Economics:	PAYBACK:		186 Months
	SAVINGS:	Wastewater treatment/disposal cost:	$10,000/yr
		Cost avoidance, fresh water:	$500/yr
		Trucking costs:	$80,000/yr
	TOTAL:		$95,000/yr

M. Federal Stock Number/Class:

N. A - 106:

A. Installation: McClellan AFB, CA

B. Installation Priority: ~~24~~ ~~30~~ ~~34~~ ~~31~~ 32

C. Project Title: Supercritical Fluid Cleaning
(Supercritical Fluid Extraction (SFE) Evaluation)

D. Project Number: PRYJ 981604

		92	94	95	96	97	98	99
E. FY:		92	94	95	96	97	98	99
F. Cost: $K,	3080		500	1500			1500	
	3400	500	250	450				450

G. Current Process: Organic solvents are commonly used to clean precision parts. Because the solvent used in these extractions must not contaminate the sample, a high degree of volatility is needed. Freon TF, 1-1-1-trichloroethane, acetone, and MEK are solvents often used to clean precision parts. However, chlorinated solvents are toxic air pollutants and highly volatile organic chemicals pose a health and fire risk.

H. New Process: The new process uses a supercritical fluid to dissolve the material being extracted and uses a phase change to eliminate the super-critical fluid. Ultrahigh purity cleaning of precision parts is possible.

I. Environmental Benefits: Eliminates the use of hazardous solvents in chemical cleaning operations; improves employee safety.

J. Maintainability/Reliability Benefits: Automated process vs. manual operation.

K. Impact on Mission: Improves precision cleaning of critical precision parts.

L. Economics: PAYBACK = ~~120~~ 18.08 Months
Savings based on reducing/eliminating hazardous chemicals/wastes while increasing productivity = $150K/yr

M. Federal Stock Number/Class:

N. A - 106:

A. Installation: McClellan AFB, CA

B. Installation Priority: ~~41 39 41~~ 43

C. Project Title: Waste Recycle Equipment

D. Project Number: PRYJ 921643

E. FY: 92 94 95 96 97 98 99

F. Cost: $K, 3080 190

3400 210

G. Current Process: Small metal containers are manually handled. Do not have other requested equipment.

H. New Process: Will lease or buy one 1.5 ton truck with cover and lift, one 15 ton/hr wood and lumber chipper, one 10 ton/hr tire chipper, one fork lift and 500 roll type containers.

I. Environmental Benefits: Will improve our ability to handle non hazardous waste and reduce volumes of bulky material. Material can be recycled instead of disposing in county landfill.

J. Maintainability/Reliability Benefits:

K. Impact on Mission: Improved public relations

L. Economics: PAYBACK = 1.97 24 Months
SAVINGS = Reduced manpower
Avoid disposal costs

M. Federal Stock Number/Class:

N. A - 106:

A. Installation: McClellan AFB, CA

B. Installation Priority: ~~39~~ ~~54~~ ~~64~~ ~~65~~ 66

C. Project Title: Photopyrolysis Depaint System

D. Project Number: PRJY 921610

E. FY:		92	94	95	96	97	98	99
F. Cost: $K,	3080			700				
	3400	325	250	150				

G. Current Process: Paint removal using bead blasting and/or chemical strippers

H. New Process: Develop and evaluate photopyrolysis technologies to depaint aircraft surfaces.

I. Environmental Benefits: Minimize hazardous waste & reduce toxic air emission

J. Maintainability/Reliability Benefits: Reduce man-hours in depaint process

K. Impact on Mission: Reduce hazardous waste

L. Economics: Payback: = 5.0 60 ~~74~~ months
Savings = $220K/yr

M. Federal Stock Number/Class:

N. A - 106:

Pollution Prevention Project Submittal

Installation: Hill AFB
Installation Priority: 6
Project Title: Phaseout of Ozone Depleting Chemicals in LIL, ph II
Project Number: KRSM 940727, ph II
FY: 95
Cost/Appropriation: 160k/3080, 75k/3400

Current Process: A vapor degreaser (TCA is the solvent) is used in the spray shop in bldg 511.

New Process: Phase II involves design, site preparation and installment of a high efficiency HCFC vapor degreaser.

Environmental Benefits: See original submittal (FY94).

Maintainability/Reliability Benefits: Unknown

Impact on Mission: The more efficient system should save on labor, utility, and material costs and reduce flow time.

Economics: See original submittal.

Federal Stock Number/Class: Unknown
A-106: Not in A-106

Project No: KRSM 920797
Pollution Prevention Opportunity Assessment (PPOA), phase II

Date: Mar 92
FY: 92
Category: Pollution Prevention
Installation: Hill AFB

Current Process: The EPA has targeted the following substances for reduction in the work place: chromium, trichloroethlene, perchloroethylene, chloroform, 1,1,1 trichloroethane, cadmium, methylene chloride, cyanide, lead, mercury, nickel, carbon tetrachloride, methy ethyl ketone, methyl isobutyl ketone, toluene, xylene, benzene and ozone depleters. Most of these substances are found in the materials used and in the waste streams at Hill AFB.

New Process: A pollution prevention opportunity assessment will identify processes that use or generate these substances. Following guidelines published in EPA/625/7-88/003, the contractor will flow chart processes that involve these substances, compile detailed data on costs and quanities associated with these substances, perform a feasibility study of currently available source reduction/recycling options, and identify research needs. This will be a shop-by-shop base-wide study.

Environmental Benefits: We expect the goal of the new Air Force Pollution Prevention Program to be zero discharge.This means that pollution in all medias will be controlled, captured and reused, or not generated. Benefits include short term cutbacks and long term elimination (ideally) of disposal costs, of worker exposure, of long term liability, of bad public relations, of treatment costs, of pollution abatement costs, and of permitting/reporting costs.

Economics: Savings of a PPOA are difficult to calculate in advance because the point of the study is to identify savings and implementation costs. We do, however, know some present costs of polluting:

$1,200,000/yr in hazardous waste disposal
$ 450,000/yr in solid waste disposal
$1,400,000/yr in waste water treatment
$1,200,000/yr in air pollution control
$4,250,000/yr TOTAL (utilities, labor, permitting/reporting, potential for liability and worker exposure, etc are not included in this figure).

Savings: If the study initially identifies initiatives which result in a modest 10% savings (conservative estimate), the savings are $425,000.

KRSM 920797, Page 2

Estimated Cost: $304,000
Payback Period: 0.72 year
Fund Appropriation: 3400

Federal Stock No/Class: N/A
Application To Others: Air Force wide, especially ALC centers.

Note: Phase I involved the obligation of $500k -- the additional $304k is needed to finish the project.

DATE: Mar 1991

KRSM 870172
Waste Oil Boiler

FY: 92

CATEGORY: Pollution Prevention

INSTALLATION: Hill AFB

CURRENT PROCESS: Waste oil is turned into DRMO for disposal. DRMO gives the oil away when possible. When it is not possible to give the oil away (usually during the summer) DRMO has paid for oil disposal. In the past the oil was marketed to a local oil recycler. However, the oil recycling facility has gone out of business and become a Super Fund site. The DOD will be paying for a large portion of the site cleanup.

NEW PROCESS: This project will procure and install a boiler specifically designed to burn the waste oils we generate on base. Boilers now on base can burn either fuel oil or natural gas. However, they are not suitable for burning our waste oil. This boiler will recover energy for use on base and will eliminate the liability of sending oil off base. The boiler design (paid for with FY89 DERA funds) is complete, and the Utah Bureau of Air Quality has issued a permit. The bolier will be located by bldg 1701.

ENVIRONMENTAL BENEFITS: This project will eliminate 100,000 gallons/year of waste oil from being shipped off base. Not shipping waste oil off base will eliminate the potential for incurring liability from mishaps during disposal and transportation. The project will also provide steam for heating on base.

ECONOMICS:

SAVINGS:	HW disposal cost	$25,000/yr
	Energy savings	$30,000/yr
	Liability savings	$100,000/yr *
	Totals	$155,000/yr

* The Air Force portion of cleaning up the abandoned Ekotech oil recycling center is conservatively estimated at 10M. If that mismanagement of used oils occurs once again in the next 100 years, the annual savings would be 1/100(10M) or 100k. Actual liability savings could be much higher if the cleanup costs are higher or if the probability of a repeat mishap is higher.

ESTIMATED COST: $296K total, $150K 3080, $146K 3400

PAYBACK PERIOD: 1.6 yr

KRSM 870172
Page 2

FUND APPROPRIATION: 3400, 3080 -

APPLICATION TO OTHERS: Other ALC bases can use a waste oil boiler to cut waste disposal liability and to recover energy from used oils.

Date: Mar 91

Project No: KRSM 920743
Waterfall Desludging Units

FY: 92

Category: Pollution Prevention

Installation: Hill AFB

Current Process: Paint sludge collects in the bottom of the waterfall paint booths (6). After the upper layer of water is routed to the IWTP for treatment, the sludge is manually removed, containerized and disposed as a hazardous waste.

New Process: Sludge is maintained in a suspended state. It is routed to a centrifuge where it is separated from the water and then containerized for disposal. The water is reused. Units will be located in bldg 220.

Environmental Benefits: Benefits include less potential for employee exposure, labor savings, hazardous waste reduction (60%), less IWTP treatment and less water usage.

Economics:

Savings: $91,500/yr Disposal (73,203# x $1.25/#)
$38,000/yr Labor ($45/hr x 845 man-hours)
$129,500 TOTAL *

* IWTP treatment/water usage savings are unknown due to lack of flow meters

Cost: $60,000

Payback Period: 5.5 months

Fund Appropriation: 3080

Federal Stock No/Class: 4940

Application To Others: Any paint shop in the DOD that uses waterfall paint booths.

POLLUTION PREVENTION PROJECT SUBMITTAL

Installation: Hill AFB, UT

Installation Priority: Three

Project Title: Off-Base Jet Noise Abatement, Phase I

Project Number: KRSM 960732

FY: 96

Cost/Appropriation: $1M/3600

Current Process: Off-base residents call the public affairs office to complain about jet noise.

New Process: Equipment will be installed to abate off-base jet noise. Phase I is a research project to investigate the feasibility of using new technology. Briefly, receivers detect incoming noise and broadcast a mirror image from the opposite direction. The waves cancel and the noise is abated.

Environmental Benefits: Public health is ensured, and public nuisance is eliminated.

Maintainability/Reliability Benefits: Unknown

Impact on Mission: If unfunded, we will continue to receive noise complaints which could involve legal implications.

Economics: Intangible. Public health, public goodwill, and liability avoidance are important but hard to quantify.

Federal Stock Number/Class: Unknown

Appendix F: Original Data from Wright-Patterson /.⁻B

Baseline Pollution Prevention Audits

Financial Considerations:

Total Cost (dollar value)	$1,000,000
Net Present Value (if available/applicable)	N/A
Payback Period (if available/applicable)	N/A
Obligation Rate of Requesting Base (Spending Record) (MAJCOM use only)	----
Ready to execute or not (ready to advertise) (yes/no)	YES
Return on Investment (if available/applicable)	N/A
Savings generated (Lifetime) (if available/applicable)	N/A
Equitable distribution of funds to all bases in command? (MAJCOM use only)	----
Equitable distribution of funds to all environmental programs? (MAJCOM use only)	----

Political Sensitivity of Project (Score on a scale from a low of 1 to a high of 10):

* Attention from Regulators (Federal, State, Local)	5,5,2
* Attention from Public (Local, National)	2,2
* Attention from Congressional Sources (Federal, State)	5,5
* Attention from MAJCOM Department of Defense Leaders	10
* Attention from Local Department of Defense Leaders	10
* Attention from Air Staff	10

Other:

* Safety Risk/Benefit (Hi=10, Med=5, Lo=0)	5
* Health Risk/Benefit (Hi=10, Med=5, Lo=0)	5
* Contribution to/Enhancement of Environment (Hi=10, Med=5, Lo=0)	10
Base Priority	10
* Potential for meeting future requirement/law/regulation (Hi=10, Med=5, Lo=0)	1
Is technology available? (yes/no)	YES
* Public Relations Contribution (Hi=10, Med=5, Lo=0)	10

Comments/Additions:

Project will identify potential pollution prevention opportunities basewide to meet long-term Air Force waste reduction goals.

* Qualitative Criteria

Appendix F (continued): Original Data from Wright-Patterson AFB

Freon Recovery, Recycling and Storage Equipment

Financial Considerations:

Total Cost (dollar value)	$150,000
Net Present Value (if available/applicable)	$150,000
Payback Period (if available/applicable)	N/A
Obligation Rate of Requesting Base (Spending Record) (MAJCOM use only)	----
Ready to execute or not (ready to advertise) (yes/no)	YES
Return on Investment (if available/applicable)	N/A
Savings generated (Lifetime) (if available/applicable)	N/A
Equitable distribution of funds to all bases in command? (MAJCOM use only)	----
Equitable distribution of funds to all environmental programs? (MAJCOM use only)	----

Political Sensitivity of Project (Score on a scale from a low of 1 to a high of 10):

* Attention from Regulators (Federal, State, Local)	8,5,5
* Attention from Public (Local, National)	5,1
* Attention from Congressional Sources (Federal, State)	10,10
* Attention from MAJCOM Department of Defense Leaders	10
* Attention from Local Department of Defense Leaders	10
* Attention from Air Staff	10

Other:

* Safety Risk/Benefit (Hi=10, Med=5, Lo=0)	5
* Health Risk/Benefit (Hi=10, Med=5, Lo=0)	10
* Contribution to/Enhancement of Environment (Hi=10, Med=5, Lo=0)	10
Base Priority	10
* Potential for meeting future requirement/law/regulation (Hi=10, Med=5, Lo=0)	2
Is technology available? (yes/no)	YES
* Public Relations Contribution (Hi=10, Med=5, Lo=0)	10

Comments/Additions:

Equipment will reduce the release of ozone depleting chemicals from air conditioning systems.

* Qualitative Criteria

Appendix F (continued): Original Data from Wright-Patterson AFB

Replace Refrigeration Purge Units

Financial Considerations:

Total Cost (dollar value)	$150,000
Net Present Value (if available/applicable)	$150,000
Payback Period (if available/applicable)	N/A
Obligation Rate of Requesting Base (Spending Record) (MAJCOM use only)	----
Ready to execute or not (ready to advertise) (yes/no)	YES
Return on Investment (if available/applicable)	N/A
Savings generated (Lifetime) (if available/applicable)	N/A
Equitable distribution of funds to all bases in command? (MAJCOM use only)	----
Equitable distribution of funds to all environmental programs? (MAJCOM use only)	----

Political Sensitivity of Project (Score on a scale from a low of 1 to a high of 10):

* Attention from Regulators (Federal, State, Local)	8,5,5
* Attention from Public (Local, National)	5,1
* Attention from Congressional Sources (Federal, State)	10,10
* Attention from MAJCOM Department of Defense Leaders	10
* Attention from Local Department of Defense Leaders	10
* Attention from Air Staff	10

Other:

* Safety Risk/Benefit (Hi=10, Med=5, Lo=0)	5
* Health Risk/Benefit (Hi=10, Med=5, Lo=0)	10
* Contribution to/Enhancement of Environment (Hi=10, Med=5, Lo=0)	10
Base Priority	10
* Potential for meeting future requirement/law/regulation (Hi=10, Med=5, Lo=0)	3
Is technology available? (yes/no)	YES
* Public Relations Contribution (Hi=10, Med=5, Lo=0)	10

Comments/Additions:

Replaces existing equipment to reduce the release of ozone depleting chemicals from air conditioning systems.

* Qualitative Criteria

Appendix F (continued): Original Data from Wright-Patterson AFB

Needleless Intravenous System

Financial Considerations:

Total Cost (dollar value)	$83,000
Net Present Value (if available/applicable)	$83,000
Payback Period (if available/applicable)	N/A
Obligation Rate of Requesting Base (Spending Record) (MAJCOM use only)	----
Ready to execute or not (ready to advertise) (yes/no)	YES
Return on Investment (if available/applicable)	N/A
Savings generated (Lifetime) (if available/applicable)	N/A
Equitable distribution of funds to all bases in command? (MAJCOM use only)	----
Equitable distribution of funds to all environmental programs? (MAJCOM use only)	----

Political Sensitivity of Project (Score on a scale from a low of 1 to a high of 10):

* Attention from Regulators (Federal, State, Local)	1,1,1
* Attention from Public (Local, National)	10,1
* Attention from Congressional Sources (Federal, State)	5,5
* Attention from MAJCOM Department of Defense Leaders	10
* Attention from Local Department of Defense Leaders	10
* Attention from Air Staff	10

Other:

* Safety Risk/Benefit (Hi=10, Med=5, Lo=0)	10
* Health Risk/Benefit (Hi=10, Med=5, Lo=0)	10
* Contribution to/Enhancement of Environment (Hi=10, Med=5, Lo=0)	10
Base Priority	4
* Potential for meeting future requirement/law/regulation (Hi=10, Med=5, Lo=0)	10
Is technology available? (yes/no)	YES
* Public Relations Contribution (Hi=10, Med=5, Lo=0)	10

Comments/Additions:

Project received very favorable coverage from local press. Reduces infectious waste and increases safety for hospital workers.

* Qualitative Criteria

Appendix F (continued): Original Data from Wright-Patterson AFB

Electronic Imaging System

Financial Considerations:

Total Cost (dollar value)	$1,400,000
Net Present Value (if available/applicable)	N/A
Payback Period (if available/applicable)	3.4 Yrs
Obligation Rate of Requesting Base (Spending Record) (MAJCOM use only)	---
Ready to execute or not (ready to advertise) (yes/no)	YES
Return on Investment (if available/applicable)	Same as Payback Period
Savings generated (Lifetime) (if available/applicable)	N/A
Equitable distribution of funds to all bases in command? (MAJCOM use only)	---
Equitable distribution of funds to all environmental programs? (MAJCOM use only)	---

Political Sensitivity of Project (Score on a scale from a low of 1 to a high of 10):

* Attention from Regulators (Federal, State, Local)	1,5,1
* Attention from Public (Local, National)	5,1
* Attention from Congressional Sources (Federal, State)	5,5
* Attention from MAJCOM Department of Defense Leaders	10
* Attention from Local Department of Defense Leaders	10
* Attention from Air Staff	8

Other:

* Safety Risk/Benefit (Hi=10, Med=5, Lo=0)	10
* Health Risk/Benefit (Hi=10, Med=5, Lo=0)	10
* Contribution to/Enhancement of Environment (Hi=10, Med=5, Lo=0)	10
Base Priority	7
* Potential for meeting future requirement/law/regulation (Hi=10, Med=5, Lo=0)	10
Is technology available? (yes/no)	YES
* Public Relations Contribution (Hi=10, Med=5, Lo=0)	10

Comments/Additions:

New system will eliminate 2,700,000 gallons of wastewater and $283,000 in photographic chemicals per year for this photography laboratory.

* Qualitative Criteria

Appendix G: Original Data from McClellan AFB

Repelletize/Reuse Spent Plastic Media Beads (SM-931602)

Financial Considerations:

Total Cost (dollar value)	$250,000
Net Present Value (if available/applicable)	$242,000
Payback Period (if available/applicable)	3.1 Yrs
Obligation Rate of Requesting Base (Spending Record) (MAJCOM use only)	----
Ready to execute or not (ready to advertise) (yes/no)	YES
Return on Investment (if available/applicable)	32%
Savings generated (Lifetime) (if available/applicable)	$80,000/Yr
Equitable distribution of funds to all bases in command? (MAJCOM use only)	----
Equitable distribution of funds to all environmental programs? (MAJCOM use only)	----

Political Sensitivity of Project (Score on a scale from a low of 1 to a high of 10):

* Attention from Regulators (Federal, State, Local)	3
* Attention from Public (Local, National)	6
* Attention from Congressional Sources (Federal, State)	2
* Attention from MAJCOM Department of Defense Leaders	3
* Attention from Local Department of Defense Leaders	6
* Attention from Air Staff	2

Other:

* Safety Risk/Benefit (Hi=10, Med=5, Lo=0)	0
* Health Risk/Benefit (Hi=10, Med=5, Lo=0)	0
* Contribution to/Enhancement of Environment (Hi=10, Med=5, Lo=0)	5
Base Priority	1
* Potential for meeting future requirement/law/regulation (Hi=10, Med=5, Lo=0)	10
Is technology available? (yes/no)	NO
*Public Relations Contribution (Hi=10, Med=5, Lo=0)	5

Comments/Additions:

* Qualitative Criteria

Aircraft Corrosion Control Recycle Equipment (SM-921602)

Financial Considerations:

Total Cost (dollar value)	$1,475,000
Net Present Value (if available/applicable)	$891,000
Payback Period (if available/applicable)	15.5 Yrs
Obligation Rate of Requesting Base (Spending Record) (MAJCOM use only)	---
Ready to execute or not (ready to advertise) (yes/no)	YES
Return on Investment (if available/applicable)	6%
Savings generated (Lifetime) (if available/applicable)	$95,000/Yr
Equitable distribution of funds to all bases in command? (MAJCOM use only)	---
Equitable distribution of funds to all environmental programs? (MAJCOM use only)	---

Political Sensitivity of Project (Score on a scale from a low of 1 to a high of 10):

* Attention from Regulators (Federal, State, Local)	6
* Attention from Public (Local, National)	4
* Attention from Congressional Sources (Federal, State)	1
* Attention from MAJCOM Department of Defense Leaders	2
* Attention from Local Department of Defense Leaders	8
* Attention from Air Staff	2

Other:

* Safety Risk/Benefit (Hi=10, Med=5, Lo=0)	0
* Health Risk/Benefit (Hi=10, Med=5, Lo=0)	0
* Contribution to/Enhancement of Environment (Hi=10, Med=5, Lo=0)	5
Base Priority	2
* Potential for meeting future requirement/law/regulation (Hi=10, Med=5, Lo=0)	10
Is technology available? (yes/no)	YES
*Public Relations Contribution (Hi=10, Med=5, Lo=0)	5

Comments/Additions:

* Qualitative Criteria

Appendix G (continued): Original Data from McClellan AFB

Supercritical Fluid Cleaning (SM-981604)

Financial Considerations:

Total Cost (dollar value)	$2,700,000
Net Present Value (if available/applicable)	$1,778,000
Payback Period (if available/applicable)	18 Yrs
Obligation Rate of Requesting Base (Spending Record) (MAJCOM use only)	----
Ready to execute or not (ready to advertise) (yes/no)	YES
Return on Investment (if available/applicable)	6%
Savings generated (Lifetime) (if available/applicable)	$150,000/Yr
Equitable distribution of funds to all bases in command? (MAJCOM use only)	----
Equitable distribution of funds to all environmental programs? (MAJCOM use only)	----

Political Sensitivity of Project (Score on a scale from a low of 1 to a high of 10):

* Attention from Regulators (Federal, State, Local)	8
* Attention from Public (Local, National)	7
* Attention from Congressional Sources (Federal, State)	8
* Attention from MAJCOM Department of Defense Leaders	8
* Attention from Local Department of Defense Leaders	9
* Attention from Air Staff	8

Other:

* Safety Risk/Benefit (Hi=10, Med=5, Lo=0)	5
* Health Risk/Benefit (Hi=10, Med=5, Lo=0)	5
* Contribution to/Enhancement of Environment (Hi=10, Med=5, Lo=0)	9
Base Priority	3
* Potential for meeting future requirement/law/regulation (Hi=10, Med=5, Lo=0)	10
Is technology available? (yes/no)	NO
*Public Relations Contribution (Hi=10, Med=5, Lo=0)	10

Comments/Additions:

* Qualitative Criteria

Waste Recycle Equipment (SM-921643)

Financial Considerations:

Total Cost (dollar value)	$190,000
Net Present Value (if available/applicable)	$424,000
Payback Period (if available/applicable)	1.9 Yrs
Obligation Rate of Requesting Base (Spending Record) (MAJCOM use only)	----
Ready to execute or not (ready to advertise) (yes/no)	YES
Return on Investment (if available/applicable)	53%
Savings generated (Lifetime) (if available/applicable)	$100,000/Yr
Equitable distribution of funds to all bases in command? (MAJCOM use only)	----
Equitable distribution of funds to all environmental programs? (MAJCOM use only)	----

Political Sensitivity of Project (Score on a scale from a low of 1 to a high of 10):

* Attention from Regulators (Federal, State, Local)	2
* Attention from Public (Local, National)	3
* Attention from Congressional Sources (Federal, State)	2
* Attention from MAJCOM Department of Defense Leaders	2
* Attention from Local Department of Defense Leaders	4
* Attention from Air Staff	2

Other:

* Safety Risk/Benefit (Hi=10, Med=5, Lo=0)	0
* Health Risk/Benefit (Hi=10, Med=5, Lo=0)	0
* Contribution to/Enhancement of Environment (Hi=10, Med=5, Lo=0)	5
Base Priority	4
* Potential for meeting future requirement/law/regulation (Hi=10, Med=5, Lo=0)	0
Is technology available? (yes/no)	YES
*Public Relations Contribution (Hi=10, Med=5, Lo=0)	5

Comments/Additions:

* Qualitative Criteria

Photopyrolysis Depaint System (SM-921610)

Financial Considerations:

Total Cost (dollar value)	$1,100,000
Net Present Value (if available/applicable)	$252,000
Payback Period (if available/applicable)	5 Yrs
Obligation Rate of Requesting Base (Spending Record) (MAJCOM use only)	----
Ready to execute or not (ready to advertise) (yes/no)	YES
Return on Investment (if available/applicable)	20%
Savings generated (Lifetime) (if available/applicable)	$220,000/Yr
Equitable distribution of funds to all bases in command? (MAJCOM use only)	----
Equitable distribution of funds to all environmental programs? (MAJCOM use only)	----

Political Sensitivity of Project (Score on a scale from a low of 1 to a high of 10):

* Attention from Regulators (Federal, State, Local)	10
* Attention from Public (Local, National)	8
* Attention from Congressional Sources (Federal, State)	3
* Attention from MAJCOM Department of Defense Leaders	4
* Attention from Local Department of Defense Leaders	8
* Attention from Air Staff	3

Other:

* Safety Risk/Benefit (Hi=10, Med=5, Lo=0)	10
* Health Risk/Benefit (Hi=10, Med=5, Lo=0)	10
* Contribution to/Enhancement of Environment (Hi=10, Med=5, Lo=0)	10
Base Priority	5
* Potential for meeting future requirement/law/regulation (Hi=10, Med=5, Lo=0)	10
Is technology available? (yes/no)	NO
*Public Relations Contribution (Hi=10, Med=5, Lo=0)	10

Comments/Additions:

* Qualitative Criteria

Appendix H: Original Data from Hill AFB

Phaseout of Ozone Depleting Chemicals (OO-940727)

Financial Considerations:

Total Cost (dollar value)	$3,895
Net Present Value (if available/applicable)	N/A
Payback Period (if available/applicable)	0
Obligation Rate of Requesting Base (Spending Record) (MAJCOM use only)	----
Ready to execute or not (ready to advertise) (yes/no)	YES
Return on Investment (if available/applicable)	N/A
Savings generated (Lifetime) (if available/applicable)	N/A
Equitable distribution of funds to all bases in command? (MAJCOM use only)	----
Equitable distribution of funds to all environmental programs? (MAJCOM use only)	----

Political Sensitivity of Project (Score on a scale from a low of 1 to a high of 10):

* Attention from Regulators (Federal, State, Local)	10
* Attention from Public (Local, National)	10
* Attention from Congressional Sources (Federal, State)	10
* Attention from MAJCOM Department of Defense Leaders	10
* Attention from Local Department of Defense Leaders	10
* Attention from Air Staff	10

Other:

* Safety Risk/Benefit (Hi=10, Med=5, Lo=0)	10
* Health Risk/Benefit (Hi=10, Med=5, Lo=0)	10
* Contribution to/Enhancement of Environment (Hi=10, Med=5, Lo=0)	10
Base Priority	1
* Potential for meeting future requirement/law/regulation (Hi=10, Med=5, Lo=0)	10
Is technology available? (yes/no)	YES
* Public Relations Contribution (Hi=10, Med=5, Lo=0)	10

Comments/Additions:

* Qualitative Criteria

Pollution Prevention Opportunity Assessment (OO-920797)

Financial Considerations:

Total Cost (dollar value)	$304,000
Net Present Value (if available/applicable)	N/A
Payback Period (if available/applicable)	0.72 Yrs
Obligation Rate of Requesting Base (Spending Record) (MAJCOM use only)	----
Ready to execute or not (ready to advertise) (yes/no)	YES
Return on Investment (if available/applicable)	N/A
Savings generated (Lifetime) (if available/applicable)	$425/Yr
Equitable distribution of funds to all bases in command? (MAJCOM use only)	----
Equitable distribution of funds to all environmental programs? (MAJCOM use only)	----

Political Sensitivity of Project (Score on a scale from a low of 1 to a high of 10):

* Attention from Regulators (Federal, State, Local)	10
* Attention from Public (Local, National)	5
* Attention from Congressional Sources (Federal, State)	10
* Attention from MAJCOM Department of Defense Leaders	10
* Attention from Local Department of Defense Leaders	10
* Attention from Air Staff	10

Other:

* Safety Risk/Benefit (Hi=10, Med=5, Lo=0)	10
* Health Risk/Benefit (Hi=10, Med=5, Lo=0)	10
* Contribution to/Enhancement of Environment (Hi=10, Med=5, Lo=0)	10
Base Priority	2
* Potential for meeting future requirement/law/regulation (Hi=10, Med=5, Lo=0)	10
Is technology available? (yes/no)	N/A
*Public Relations Contribution (Hi=10, Med=5, Lo=0)	5

Comments/Additions:

* Qualitative Criteria

Appendix H (continued): Original Data from Hill AFB

Waste Oil Boiler (OO-870172)

Financial Considerations:

Total Cost (dollar value)	$296,000
Net Present Value (if available/applicable)	N/A
Payback Period (if available/applicable)	1.6 Yrs
Obligation Rate of Requesting Base (Spending Record) (MAJCOM use only)	----
Ready to execute or not (ready to advertise) (yes/no)	YES
Return on Investment (if available/applicable)	N/A
Savings generated (Lifetime) (if available/applicable)	$155,000
Equitable distribution of funds to all bases in command? (MAJCOM use only)	----
Equitable distribution of funds to all environmental programs? (MAJCOM use only)	----

Political Sensitivity of Project (Score on a scale from a low of 1 to a high of 10):

* Attention from Regulators (Federal, State, Local)	8
* Attention from Public (Local, National)	1
* Attention from Congressional Sources (Federal, State)	1
* Attention from MAJCOM Department of Defense Leaders	5
* Attention from Local Department of Defense Leaders	1
* Attention from Air Staff	5

Other:

* Safety Risk/Benefit (Hi=10, Med=5, Lo=0)	5
* Health Risk/Benefit (Hi=10, Med=5, Lo=0)	5
* Contribution to/Enhancement of Environment (Hi=10, Med=5, Lo=0)	10
Base Priority	3
* Potential for meeting future requirement/law/regulation (Hi=10, Med=5, Lo=0)	10
Is technology available? (yes/no)	YES
*Public Relations Contribution (Hi=10, Med=5, Lo=0)	0

Comments/Additions:

* Qualitative Criteria

Appendix H (continued): Original Data from Hill AFB

Waterfall Desludging Units (OO-920743)

Financial Considerations:

Total Cost (dollar value)	$60,000
Net Present Value (if available/applicable)	N/A
Payback Period (if available/applicable)	5.5 Mos
Obligation Rate of Requesting Base (Spending Record) (MAJCOM use only)	----
Ready to execute or not (ready to advertise) (yes/no)	YES
Return on Investment (if available/applicable)	N/A
Savings generated (Lifetime) (if available/applicable)	$129,500
Equitable distribution of funds to all bases in command? (MAJCOM use only)	----
Equitable distribution of funds to all environmental programs? (MAJCOM use only)	----

Political Sensitivity of Project (Score on a scale from a low of 1 to a high of 10):

* Attention from Regulators (Federal, State, Local)	1
* Attention from Public (Local, National)	1
* Attention from Congressional Sources (Federal, State)	1
* Attention from MAJCOM Department of Defense Leaders	5
* Attention from Local Department of Defense Leaders	1
* Attention from Air Staff	8

Other:

* Safety Risk/Benefit (Hi=10, Med=5, Lo=0)	10
* Health Risk/Benefit (Hi=10, Med=5, Lo=0)	10
* Contribution to/Enhancement of Environment (Hi=10, Med=5, Lo=0)	10
Base Priority	4
* Potential for meeting future requirement/law/regulation (Hi=10, Med=5, Lo=0)	5
Is technology available? (yes/no)	YES
* Public Relations Contribution (Hi=10, Med=5, Lo=0)	10

Comments/Additions:

* Qualitative Criteria

Appendix H (continued): Original Data from Hill AFB

Off-Base Jet Noise Abatement (OO-960732)

Financial Considerations:

Total Cost (dollar value)	$1,000,000
Net Present Value (if available/applicable)	N/A
Payback Period (if available/applicable)	0
Obligation Rate of Requesting Base (Spending Record) (MAJCOM use only)	----
Ready to execute or not (ready to advertise) (yes/no)	YES
Return on Investment (if available/applicable)	N/A
Savings generated (Lifetime) (if available/applicable)	0
Equitable distribution of funds to all bases in command? (MAJCOM use only)	----
Equitable distribution of funds to all environmental programs? (MAJCOM use only)	----

Political Sensitivity of Project (Score on a scale from a low of 1 to a high of 10):

* Attention from Regulators (Federal, State, Local)	1
* Attention from Public (Local, National)	10
* Attention from Congressional Sources (Federal, State)	10
* Attention from MAJCOM Department of Defense Leaders	10
* Attention from Local Department of Defense Leaders	10
* Attention from Air Staff	10

Other:

* Safety Risk/Benefit (Hi=10, Med=5, Lo=0)	5
* Health Risk/Benefit (Hi=10, Med=5, Lo=0)	5
* Contribution to/Enhancement of Environment (Hi=10, Med=5, Lo=0)	10
Base Priority	5
* Potential for meeting future requirement/law/regulation (Hi=10, Med=5, Lo=0)	10
Is technology available? (yes/no)	NO
* Public Relations Contribution (Hi=10, Med=5, Lo=0)	10

Comments/Additions:

* Qualitative Criteria

Appendix I: Attributes Selected by AFMC

ATTRIBUTES

Financial Considerations:

Total Cost
Payback Period
Obligation Rate of Requesting Base (Spending Record)
Ready to execute or not (ready to advertise)

Political Sensitivity of Project:

* Attention from Local Sources (Regulators, Public, Base and Wing Commanders)
* Attention from National Sources (Congressional, MAJCOM, Air Staff)

Other:

* Safety Risk/Benefit
* Health Risk/Benefit
* Contribution to/Enhancement of Environment
Base Priority

Comments/Additions:

* Qualitative Criteria

Appendix J: Original Data, First Iteration

AFMC Bases: Hill AFB, McClellan, Wright-Patterson AFB

Original Data Table

Project Number	Project Title	Total Cost ($1000s)	Payback Period (yrs)	Oblig Rate	Ready to Execute	Local Attn	Natl Attn	Safety Risk	Health Risk	Env Contrib	Base Priority
SM-931602	Repelletize/Reuse Spent Plastic Media Beads	-250	3.1	1	10	50.0000	2.33	1	1	5	1
SM-921602	Aircraft Corrosion Control Recycle Equipment	-1475	15.5	1	10	6	1.67	1	1	5	2
SM-981604	Supercritical Fluid Cleaning	-2700	18	1	10	7.67	8	5	5	10	3
SM-921643	Waste Recycle Equipment	-190	1.9	1	10	3	2	1	1	5	4
SM-921610	Photopyrolysis Depaint System	-1100	5	1	10	8.67	3.67	10	10	10	5
WP-xxxxxx	Baseline Pollution Prevention Audits	-1000	30	1	10	5.33	8.33	5	5	10	1
WP-xxxxxx	Freon Recovery, Recycling and Storage Eqpt	-150	30	1	10	6.33	10	5	10	10	2
WP-xxxxxx	Replace Refrigeration Purge Units	-150	30	1	10	6.33	10	5	10	10	3
WP-xxxxxx	Needleless Intravenous System	-83	30	1	10	5.5	8.33	10	10	10	4
WP-xxxxxx	Electronic Imaging System	-1400	3.4	1	10	5.11	7.67	10	10	10	5
OO-940727	Phaseout of Ozone Depleting Chemicals	-3895	30	1	10	10	10	10	10	10	1
OO-920797	Pollution Prevention Opportunity Assessment	-304	0.72	1	10	8.33	10	10	10	10	2
OO-870172	Waste Oil Boiler	-296	1.6	1	10	3.33	3.67	5	5	10	3
OO-920743	Waterfall Desludging Units	-60	5.5	1	10	1	4.67	10	10	10	4
OO-960732	Off-Base Jet Noise Abatement	-1000	30	1	10	7	10	5	5	10	5
"Best" Number in Each Column		-60	0.72	1	10	10	10	10	10	10	1

Appendix J (continued): Original Data, First Iteration

Degrees of Closeness Table (d)

Project Number	Project Title	Total Cost ($1000s)	Payback Period (yrs)	Oblig Rate	Ready to Execute	Local Attn	Natl Attn	Safety Risk	Health Risk	Env Contrib	Base Priority
SM-931602	Repelletize/Reuse Spent Plastic Media Beads	4.1667	4.3056	1.0000	1.0000	0.5000	0.2330	0.1000	0.1000	0.5000	1.0000
SM-921602	Aircraft Corrosion Control Recycle Equipment	24.5833	21.5278	1.0000	1.0000	0.6000	0.1670	0.1000	0.1000	0.5000	2.0000
SM-981604	Supercritical Fluid Cleaning	45.0000	25.0000	1.0000	1.0000	0.7670	0.8000	0.5000	0.5000	1.0000	3.0000
SM-921643	Waste Recycle Equipment	3.1667	2.6389	1.0000	1.0000	0.3000	0.2000	0.1000	0.1000	0.5000	4.0000
SM-921610	Photopyrolysis Depaint System	18.3333	6.9444	1.0000	1.0000	0.8670	0.3670	1.0000	1.0000	1.0000	5.0000
WP-xxxxxx	Baseline Pollution Prevention Audits	16.6667	41.6667	1.0000	1.0000	0.5330	0.8330	0.5000	0.5000	1.0000	1.0000
WP-xxxxxx	Freon Recovery, Recycling and Storage Eqpt	2.5000	41.6667	1.0000	1.0000	0.6330	1.0000	0.5000	1.0000	1.0000	2.0000
WP-xxxxxx	Replace Refrigeration Purge Units	2.5000	41.6667	1.0000	1.0000	0.6330	1.0000	0.5000	1.0000	1.0000	3.0000
WP-xxxxxx	Needleless Intravenous System	1.3833	41.6667	1.0000	1.0000	0.5500	0.8330	1.0000	1.0000	1.0000	4.0000
WP-xxxxxx	Electronic Imaging System	23.3333	4.7222	1.0000	1.0000	0.5110	0.7670	1.0000	1.0000	1.0000	5.0000
OO-940727	Phaseout of Ozone Depleting Chemicals	64.9167	41.6667	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
OO-920797	Pollution Prevention Opportunity Assessment	5.0667	1.0000	1.0000	1.0000	0.8330	1.0000	1.0000	1.0000	1.0000	2.0000
OO-870172	Waste Oil Boiler	4.9333	2.2222	1.0000	1.0000	0.3330	0.3670	0.5000	0.5000	1.0000	3.0000
OO-920743	Waterfall Desludging Units	1.0000	7.6389	1.0000	1.0000	0.1000	0.4670	1.0000	1.0000	1.0000	4.0000
OO-960732	Off-Base Jet Noise Abatement	16.6667	41.6667	1.0000	1.0000	0.7000	1.0000	0.5000	0.5000	1.0000	5.0000
	Column Total (D)	234.2167	326.0000	15.0000	15.0000	8.8600	10.0340	9.3000	10.3000	13.5000	45.0000

Appendix J (continued): Original Data, First Iteration

Values Calculated for (d)/(D)

Project Number	Project Title	Total Cost ($1000s)	Payback Period (yrs)	Oblig Rate	Ready to Execute	Local Attn	Natl Attn	Safety Risk	Health Risk	Env Contrib	Base Priority
SM-931602	Repelletize/Reuse Spent Plastic Media Beads	0.0178	0.0132	0.0667	0.0667	0.0564	0.0232	0.0108	0.0097	0.0370	0.0222
SM-921602	Aircraft Corrosion Control Recycle Equipment	0.1050	0.0660	0.0667	0.0667	0.0677	0.0166	0.0108	0.0097	0.0370	0.0444
SM-981604	Supercritical Fluid Cleaning	0.1921	0.0767	0.0667	0.0667	0.0866	0.0797	0.0538	0.0485	0.0741	0.0667
SM-921643	Waste Recycle Equipment	0.0135	0.0081	0.0667	0.0667	0.0339	0.0199	0.0108	0.0097	0.0370	0.0889
SM-921610	Photopyrolysis Depaint System	0.0783	0.0213	0.0667	0.0667	0.0979	0.0366	0.1075	0.0971	0.0741	0.1111
WP-xxxxxx	Baseline Pollution Prevention Audits	0.0712	0.1278	0.0667	0.0667	0.0602	0.0830	0.0538	0.0485	0.0741	0.0222
WP-xxxxxx	Freon Recovery, Recycling and Storage Eqpt	0.0107	0.1278	0.0667	0.0667	0.0714	0.0997	0.0538	0.0971	0.0741	0.0444
WP-xxxxxx	Replace Refrigeration Purge Units	0.0107	0.1278	0.0667	0.0667	0.0714	0.0997	0.0538	0.0971	0.0741	0.0667
WP-xxxxxx	Needleless Intravenous System	0.0059	0.1278	0.0667	0.0667	0.0621	0.0830	0.1075	0.0971	0.0741	0.0889
WP-xxxxxx	Electronic Imaging System	0.0996	0.0145	0.0667	0.0667	0.0577	0.0764	0.1075	0.0971	0.0741	0.1111
OO-940727	Phaseout of Ozone Depleting Chemicals	0.2772	0.1278	0.0667	0.0667	0.1129	0.0997	0.1075	0.0971	0.0741	0.0222
OO-920797	Pollution Prevention Opportunity Assessment	0.0216	0.0031	0.0667	0.0667	0.0940	0.0997	0.1075	0.0971	0.0741	0.0444
OO-870172	Waste Oil Boiler	0.0211	0.0068	0.0667	0.0667	0.0376	0.0366	0.0538	0.0485	0.0741	0.0667
OO-920743	Waterfall Desludging Units	0.0043	0.0234	0.0667	0.0667	0.0113	0.0465	0.1075	0.0971	0.0741	0.0889
OO-960732	Off-Base Jet Noise Abatement	0.0712	0.1278	0.0667	0.0667	0.0790	0.0997	0.0538	0.0485	0.0741	0.1111
	Check	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Appendix J (continued): Original Data, First Iteration

Values Calculated for (d/D) * (natural log(d/D))

Project Number	Project Title	Total Cost ($1000s)	Payback Period (yrs)	Oblig Rate	Ready to Execute	Local Attn	Natl Attn	Safety Risk	Health Risk	Env Contrib	Base Priority
SM-931602	Repelletize/Reuse Spent Plastic Media Beads	-0.0717	-0.0571	-0.1805	-0.1805	-0.1622	-0.0874	-0.0487	-0.0450	-0.1221	-0.0846
SM-921602	Aircraft Corrosion Control Recycle Equipment	-0.2366	-0.1795	-0.1805	-0.1805	-0.1823	-0.0682	-0.0487	-0.0450	-0.1221	-0.1384
SM-981604	Supercritical Fluid Cleaning	-0.3169	-0.1969	-0.1805	-0.1805	-0.2118	-0.2016	-0.1572	-0.1469	-0.1928	-0.1805
SM-921643	Waste Recycle Equipment	-0.0582	-0.0390	-0.1805	-0.1805	-0.1146	-0.0780	-0.0487	-0.0450	-0.1221	-0.2151
SM-921610	Photopyrolysis Depaint System	-0.1994	-0.0820	-0.1805	-0.1805	-0.2274	-0.1210	-0.2398	-0.2264	-0.1928	-0.2441
WP-xxxxxx	Baseline Pollution Prevention Audits	-0.1881	-0.2629	-0.1805	-0.1805	-0.1691	-0.2066	-0.1572	-0.1469	-0.1928	-0.0846
WP-xxxxxx	Freon Recovery, Recycling and Storage Eqpt	-0.0485	-0.2629	-0.1805	-0.1805	-0.1885	-0.2298	-0.1572	-0.2264	-0.1928	-0.1384
WP-xxxxxx	Replace Refrigeration Purge Units	-0.0485	-0.2629	-0.1805	-0.1805	-0.1885	-0.2298	-0.1572	-0.2264	-0.1928	-0.1805
WP-xxxxxx	Needleless Intravenous System	-0.0303	-0.2629	-0.1805	-0.1805	-0.1725	-0.2066	-0.2398	-0.2264	-0.1928	-0.2151
WP-xxxxxx	Electronic Imaging System	-0.2298	-0.0613	-0.1805	-0.1805	-0.1645	-0.1965	-0.2398	-0.2264	-0.1928	-0.2441
OO-940727	Phaseout of Ozone Depleting Chemicals	-0.3556	-0.2629	-0.1805	-0.1805	-0.2462	-0.2298	-0.2398	-0.2264	-0.1928	-0.0846
OO-920797	Pollution Prevention Opportunity Assessment	-0.0829	-0.0178	-0.1805	-0.1805	-0.2223	-0.2298	-0.2398	-0.2264	-0.1928	-0.1384
OO-870172	Waste Oil Boiler	-0.0813	-0.0340	-0.1805	-0.1805	-0.1233	-0.1210	-0.1572	-0.1469	-0.1928	-0.1805
OO-920743	Waterfall Desludging Units	-0.0233	-0.0880	-0.1805	-0.1805	-0.0506	-0.1428	-0.2398	-0.2264	-0.1928	-0.2151
OO-960732	Off-Base Jet Noise Abatement	-0.1881	-0.2629	-0.1805	-0.1805	-0.2005	-0.2298	-0.1572	-0.1469	-0.1928	-0.2441
Sums		-2.1591	-2.3332	-2.7081	-2.7081	-2.6247	-2.5788	-2.5279	-2.5338	-2.6797	-2.5884

Values Calculated for Entropy, e(d)

	Total Cost ($1000s)	Payback Period (yrs)	Oblig Rate	Ready to Execute	Local Attn	Natl Attn	Safety Risk	Health Risk	Env Contrib	Base Priority
e(d) = sum*(-1)/ln(m)	0.7973	0.8616	1.0000	1.0000	0.9692	0.9523	0.9335	0.9357	0.9895	0.9558

Total Entropy, E

Big E = sum(e(d))	9.3948

Values Calculated for Lambda Bars, 1/(n-E)*(1-e(d))

Lambda Bar	0.3350	0.2287	0.0000	0.0000	0.0509	0.0788	0.1099	0.1063	0.0173	0.0730

Assignment of Attribute Weights

	Financial Considerations				Political Considerations		Other			
Category Weight	0.4000				0.4000		0.2000			
	Total Cost ($1000s)	Payback Period (yrs)	Oblig Rate	Ready to Execute	Local Attn	Natl Attn	Safety Risk	Health Risk	Env Contrib	Base Priority
	0.2000	0.4000	0.1000	0.3000	0.5000	0.5000	0.1500	0.1500	0.1500	0.5500
Check	Financial Total = 1.0000				Political Total = 1.0000		Other Total = 1.0000			

Overall Attribute Weight (w)	0.0800	0.1600	0.0400	0.1200	0.2000	0.2000	0.0300	0.0300	0.0300	0.1100
Double Check	1.0000									

Calculations with Lambda Bar and Attribute Weights, Lambda Bar * (w) / Sum of Lambda Bars * (w)

Lambda Bar * (w)	0.0268	0.0366	0.0000	0.0000	0.0102	0.0158	0.0033	0.0032	0.0005	0.0080
Sum of Lambda Bar * (w)	0.1044									

Lambda	0.2567	0.3506	0.0000	0.0000	0.0975	0.1511	0.0316	0.0306	0.0050	0.0770

Appendix J (continued): Original Data, First Iteration

Deviation Table, (1 - d)

Project Number	Project Title	Total Cost ($1000s)	Payback Period (yrs)	Oblig Rate	Ready to Execute	Local Attn	Natl Attn	Safety Risk	Health Risk	Env Contrib	Base Priority
SM-931602	Repelletize/Reuse Spent Plastic Media Beads	-3.1667	-3.3056	0.0000	0.0000	0.5000	0.7670	0.9000	0.9000	0.5000	0.0000
SM-921602	Aircraft Corrosion Control Recycle Equipment	-23.5833	-20.5278	0.0000	0.0000	0.4000	0.8330	0.9000	0.9000	0.5000	-1.0000
SM-981604	Supercritical Fluid Cleaning	-44.0000	-24.0000	0.0000	0.0000	0.2330	0.2000	0.5000	0.5000	0.0000	-2.0000
SM-921643	Waste Recycle Equipment	-2.1667	-1.6389	0.0000	0.0000	0.7000	0.8000	0.9000	0.9000	0.5000	-3.0000
SM-921610	Photopyrolysis Depaint System	-17.3333	-5.9444	0.0000	0.0000	0.1330	0.6330	0.0000	0.0000	0.0000	-4.0000
WP-xxxxxx	Baseline Pollution Prevention Audits	-15.6667	-40.6667	0.0000	0.0000	0.4670	0.1670	0.5000	0.5000	0.0000	0.0000
WP-xxxxxx	Freon Recovery, Recycling and Storage Eqpt	-1.5000	-40.6667	0.0000	0.0000	0.3670	0.0000	0.5000	0.0000	0.0000	-1.0000
WP-xxxxxx	Replace Refrigeration Purge Units	-1.5000	-40.6667	0.0000	0.0000	0.3670	0.0000	0.5000	0.0000	0.0000	-2.0000
WP-xxxxxx	Needleless Intravenous System	-0.3833	-40.6667	0.0000	0.0000	0.4500	0.1670	0.0000	0.0000	0.0000	-3.0000
WP-xxxxxx	Electronic Imaging System	-22.3333	-3.7222	0.0000	0.0000	0.4890	0.2330	0.0000	0.0000	0.0000	-4.0000
OO-940727	Phaseout of Ozone Depleting Chemicals	-63.9167	-40.6667	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
OO-920797	Pollution Prevention Opportunity Assessment	-4.0667	0.0000	0.0000	0.0000	0.1670	0.0000	0.0000	0.0000	0.0000	-1.0000
OO-870172	Waste Oil Boiler	-3.9333	-1.2222	0.0000	0.0000	0.6670	0.6330	0.5000	0.5000	0.0000	-2.0000
OO-920743	Waterfall Desludging Units	0.0000	-6.6389	0.0000	0.0000	0.9000	0.5330	0.0000	0.0000	0.0000	-3.0000
OO-960732	Off-Base Jet Noise Abatement	-15.6667	-40.6667	0.0000	0.0000	0.3000	0.0000	0.5000	0.5000	0.0000	-4.0000

Absolute Value of Lambda * (1 - d)

Project Number	Project Title	Total Cost ($1000s)	Payback Period (yrs)	Oblig Rate	Ready to Execute	Local Attn	Natl Attn	Safety Risk	Health Risk	Env Contrib	Base Priority
SM-931602	Repelletize/Reuse Spent Plastic Media Beads	0.8130	1.1590	0.0000	0.0000	0.0487	0.1159	0.0284	0.0275	0.0025	0.0000
SM-921602	Aircraft Corrosion Control Recycle Equipment	6.0544	7.1976	0.0000	0.0000	0.0390	0.1258	0.0284	0.0275	0.0025	0.0770
SM-981604	Supercritical Fluid Cleaning	11.2958	8.4151	0.0000	0.0000	0.0227	0.0302	0.0158	0.0153	0.0000	0.1539
SM-921643	Waste Recycle Equipment	0.5562	0.5746	0.0000	0.0000	0.0682	0.1208	0.0284	0.0275	0.0025	0.2309
SM-921610	Photopyrolysis Depaint System	4.4499	2.0843	0.0000	0.0000	0.0130	0.0956	0.0000	0.0000	0.0000	0.3079
WP-xxxxxx	Baseline Pollution Prevention Audits	4.0220	14.2589	0.0000	0.0000	0.0455	0.0252	0.0158	0.0153	0.0000	0.0000
WP-xxxxxx	Freon Recovery, Recycling and Storage Eqpt	0.3851	14.2589	0.0000	0.0000	0.0358	0.0000	0.0158	0.0000	0.0000	0.0770
WP-xxxxxx	Replace Refrigeration Purge Units	0.3851	14.2589	0.0000	0.0000	0.0358	0.0000	0.0158	0.0000	0.0000	0.1539
WP-xxxxxx	Needleless Intravenous System	0.0984	14.2589	0.0000	0.0000	0.0439	0.0252	0.0000	0.0000	0.0000	0.2309
WP-xxxxxx	Electronic Imaging System	5.7335	1.3051	0.0000	0.0000	0.0477	0.0352	0.0000	0.0000	0.0000	0.3079
OO-940727	Phaseout of Ozone Depleting Chemicals	16.4089	14.2589	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
OO-920797	Pollution Prevention Opportunity Assessment	1.0440	0.0000	0.0000	0.0000	0.0163	0.0000	0.0000	0.0000	0.0000	0.0770
OO-870172	Waste Oil Boiler	1.0098	0.4285	0.0000	0.0000	0.0650	0.0956	0.0158	0.0153	0.0000	0.1539
OO-920743	Waterfall Desludging Units	0.0000	2.3278	0.0000	0.0000	0.0877	0.0805	0.0000	0.0000	0.0000	0.2309
OO-960732	Off-Base Jet Noise Abatement	4.0220	14.2589	0.0000	0.0000	0.0292	0.0000	0.0158	0.0153	0.0000	0.3079

Final Scores (Distances)

Project Number	Project Title	Score / Distance
SM-931602	Repelletize/Reuse Spent Plastic Media Beads	2.1950
SM-921602	Aircraft Corrosion Control Recycle Equipment	13.5523
SM-981604	Supercritical Fluid Cleaning	19.9489
SM-921643	Waste Recycle Equipment	1.6093
SM-921610	Photopyrolysis Depaint System	6.9506
WP-xxxxxx	Baseline Pollution Prevention Audits	18.3828
WP-xxxxxx	Freon Recovery, Recycling and Storage Eqpt	14.7726
WP-xxxxxx	Replace Refrigeration Purge Units	14.8495
WP-xxxxxx	Needleless Intravenous System	14.6573
WP-xxxxxx	Electronic Imaging System	7.4293
OO-940727	Phaseout of Ozone Depleting Chemicals	30.6678
OO-920797	Pollution Prevention Opportunity Assessment	1.1373
OO-870172	Waste Oil Boiler	1.7840
OO-920743	Waterfall Desludging Units	2.7269
OO-960732	Off-Base Jet Noise Abatement	18.6491

Prioritized List of Projects

Project Number	Project Title	Score / Distance
OO-920797	Pollution Prevention Opportunity Assessment	1.1373
SM-921643	Waste Recycle Equipment	1.6093
OO-870172	Waste Oil Boiler	1.7840
SM-931602	Repelletize/Reuse Spent Plastic Media Beads	2.1950
OO-920743	Waterfall Desludging Units	2.7269
SM-921610	Photopyrolysis Depaint System	6.9506
WP-xxxxxx	Electronic Imaging System	7.4293
SM-921602	Aircraft Corrosion Control Recycle Equipment	13.5523
WP-xxxxxx	Needleless Intravenous System	14.6573
WP-xxxxxx	Freon Recovery, Recycling and Storage Eqpt	14.7726
WP-xxxxxx	Replace Refrigeration Purge Units	14.8495
WP-xxxxxx	Baseline Pollution Prevention Audits	18.3828
OO-960732	Off-Base Jet Noise Abatement	18.6491
SM-981604	Supercritical Fluid Cleaning	19.9489
OO-940727	Phaseout of Ozone Depleting Chemicals	30.6678

Appendix K: Original Data, Second Iteration

SECOND ITERATION

Revised Attribute Weights:

FINANCIAL CONSIDERATIONS				POLITICAL CONSIDERATIONS		OTHER			
Total Cost	Payback Period	Obligation Rate	Ready to Execute	Local	National	Safety Risk	Health Risk	Environmental Contribution	Base Priority
0.0050	0.0050	0.0000	0.0000	0.3000	0.3000	0.0300	0.0300	0.0300	0.3000

Check Sum	1.0000

Revised Prioritized List of Projects:

Project Number	Project Title	Score/Distance
OO-920797	Pollution Prevention Opportunity Assessment	0.4426
SM-931602	Repelletize/Reuse Spent Plastic Media Beads	0.5797
WP-xxxxxx	Freon Recovery, Recycling and Storage Equipment	1.1066
OO-870172	Waste Oil Boiler	1.1352
WP-xxxxxx	Baseline Pollution Prevention Audits	1.2324
OO-920743	Waterfall Desludging Units	1.4107
WP-xxxxxx	Replace Refrigeration Purge Units	1.4167
SM-921643	Waste Recycle Equipment	1.5136
SM-921602	Aircraft Corrosion Control Recycle Equipment	1.6531
WP-xxxxxx	Needleless Intravenous System	1.7509
SM-921610	Photopyrolysis Depaint System	1.9882
WP-xxxxxx	Electronic Imaging System	2.0137
OO-940727	Phaseout of Ozone Depleting Chemicals	2.1735
SM-981604	Supercritical Fluid Cleaning	2.2150
OO-960732	Off-Base Jet Noise Abatement	2.3808

Appendix L: Original Data, Third Iteration

THIRD ITERATION

Revised Attribute Weights:

FINANCIAL CONSIDERATIONS				POLITICAL CONSIDERATIONS		OTHER			
Total Cost	Payback Period	Obligation Rate	Ready to Execute	Local	National	Safety Risk	Health Risk	Environmental Contribution	Base Priority
0.0000	0.0000	0.0000	0.0000	0.2700	0.2700	0.1000	0.0300	0.0300	0.3000

Check Sum	1.0000

Revised Prioritized List of Projects:

Project Number	Project Title	Score/Distance
OO-940727	Phaseout of Ozone Depleting Chemicals	0.0000
WP-xxxxxx	Baseline Pollution Prevention Audits	0.2382
OO-920797	Pollution Prevention Opportunity Assessment	0.3379
WP-xxxxxx	Freon Recovery, Recycling and Storage Equipment	0.4530
SM-931602	Repelletize/Reuse Spent Plastic Media Beads	0.5056
WP-xxxxxx	Replace Refrigeration Purge Units	0.7588
SM-921602	Aircraft Corrosion Control Recycle Equipment	0.8119
SM-981604	Supercritical Fluid Cleaning	0.8148
OO-870172	Waste Oil Boiler	1.0267
WP-xxxxxx	Needleless Intravenous System	1.0534
OO-920743	Waterfall Desludging Units	1.2485
OO-960732	Off-Base Jet Noise Abatement	1.3799
WP-xxxxxx	Electronic Imaging System	1.3864
SM-921610	Photopyrolysis Depaint System	1.4370
SM-921643	Waste Recycle Equipment	1.4713

Appendix M: Revised Data, First Iteration

AFMC Bases
Hill AFB, McClellan AFB, Wright-Patterson AFB

 # projects (m) = 15
 # attributes (n) = 10

	Project Number	Project Title	Total Cost Points	Payback Period Points	Obligation Rate	Ready to Execute	Local	National	Safety Risk	Health Risk	Environmental Contribution	Base Priority
1	SM-931602	Repelletize/Reuse Spent Plastic Media Beads	2.0000	4.0000	0.6700	10.0000	5.0000	2.3300	1.0000	1.0000	5.0000	1.0000
2	SM-921602	Aircraft Corrosion Control Recycle Equipment	1.0000	1.0000	0.6700	10.0000	6.0000	1.6700	1.0000	1.0000	5.0000	2.0000
3	SM-981604	Supercritical Fluid Cleaning	1.0000	1.0000	0.6700	10.0000	7.6700	8.0000	5.0000	5.0000	10.0000	3.0000
4	SM-921643	Waste Recycle Equipment	2.0000	4.0000	0.6700	10.0000	3.0000	2.0000	1.0000	1.0000	5.0000	4.0000
5	SM-921610	Photopyrolysis Depaint System	1.0000	2.0000	0.6700	10.0000	8.6700	3.6700	10.0000	10.0000	10.0000	5.0000
6	WP-xxxxxx	Baseline Pollution Prevention Audits	1.0000	3.0000	0.7000	10.0000	5.3300	8.3300	5.0000	5.0000	10.0000	1.0000
7	WP-xxxxxx	Freon Recovery Recycling and Storage Equipment	2.0000	1.0000	0.7000	10.0000	6.3300	10.0000	5.0000	10.0000	10.0000	2.0000
8	WP-xxxxxx	Replace Refrigeration Purge Units	2.0000	1.0000	0.7000	10.0000	6.3300	10.0000	5.0000	10.0000	10.0000	3.0000
9	WP-xxxxxx	Needleless Intravenous System	3.0000	1.0000	0.7000	10.0000	5.5000	8.3300	10.0000	10.0000	10.0000	4.0000
10	WP-xxxxxx	Electronic Imaging System	1.0000	2.0000	0.7000	10.0000	5.1100	7.6700	10.0000	10.0000	10.0000	5.0000
11	OO-940727	Phaseout of Ozone Depleting Chemicals	1.0000	1.0000	0.6300	10.0000	10.0000	10.0000	10.0000	10.0000	10.0000	1.0000
12	OO-920797	Pollution Prevention Assessment Opportunity	3.0000	3.0000	0.6300	10.0000	8.3300	10.0000	10.0000	10.0000	10.0000	2.0000
13	OO-870172	Waste Oil Boiler	2.0000	4.0000	0.6300	10.0000	3.3300	3.6700	5.0000	5.0000	10.0000	3.0000
14	OO-920743	Waterfall Desludging Units	3.0000	1.0000	0.6300	10.0000	1.0000	4.6700	10.0000	10.0000	10.0000	4.0000
15	OO-960732	Off-Base Jet Noise Abatement	1.0000	1.0000	0.6300	10.0000	7.0000	10.0000	5.0000	5.0000	10.0000	5.0000

Appendix M (continued): Revised Data, First Iteration

ATTRIBUTE WEIGHTS

	FINANCIAL CONSIDERATIONS				POLITICAL CONSIDERATIONS		OTHER				
	Total Cost	Payback Period	Obligation Rate	Ready to Execute	Local	National	Safety Risk	Health Risk	Environmental Contribution	Base Priority	Total Points
Points	8.0000	16.0000	4.0000	12.0000	20.0000	20.0000	3.0000	3.0000	3.0000	11.0000	100
Overall Weight (w)	0.0800	0.1600	0.0400	0.1200	0.2000	0.2000	0.0300	0.0300	0.0300	0.1100	
Check sum	1.0000										

Appendix M (continued): Revised Data, First Iteration

	Project Title	Total Cost Points	Payback Period Points	Obligation Rate	Ready to Execute	Local	National	Safety Risk	Health Risk	Environmental Contribution	Base Priority
"Best number from each of the previous columns:		3.0000	4.0000	0.7000	10.0000	10.0000	10.0000	10.0000	10.0000	10.0000	1.0000
Original data element/"best" # (d)	Repelletize/Reuse Spent Plastic Media Beads	0.6667	1.0000	0.9571	1.0000	0.5000	0.2330	0.1000	0.1000	0.5000	1.0000
	Aircraft Corrosion Control Recycle Equipment	0.3333	0.2500	0.9571	1.0000	0.6000	0.1670	0.1000	0.1000	0.5000	2.0000
	Supercritical Fluid Cleaning	0.3333	0.2500	0.9571	1.0000	0.7670	0.8000	0.5000	0.5000	1.0000	3.0000
	Waste Recycle Equipment	0.6667	1.0000	0.9571	1.0000	0.3000	0.2000	0.1000	0.1000	0.5000	4.0000
	Photopyrolysis Depaint System	0.3333	0.5000	0.9571	1.0000	0.8670	0.3670	1.0000	1.0000	1.0000	5.0000
	Baseline Pollution Prevention Audits	0.3333	0.7500	1.0000	1.0000	0.5330	0.8330	0.5000	0.5000	1.0000	1.0000
	Freon Recovery Recycling and Storage Equipment	0.6667	0.2500	1.0000	1.0000	0.6330	1.0000	0.5000	1.0000	1.0000	2.0000
	Replace Refrigeration Purge Units	0.6667	0.2500	1.0000	1.0000	0.6330	1.0000	0.5000	1.0000	1.0000	3.0000
	Needleless Intravenous System	1.0000	0.2500	1.0000	1.0000	0.5500	0.8330	1.0000	1.0000	1.0000	4.0000
	Electronic Imaging System	0.3333	0.5000	1.0000	1.0000	0.5110	0.7670	1.0000	1.0000	1.0000	5.0000
	Phaseout of Ozone Depleting Chemicals	0.3333	0.2500	0.9000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	Pollution Prevention Assessment Opportunity	1.0000	0.7500	0.9000	1.0000	0.8330	1.0000	1.0000	1.0000	1.0000	2.0000
	Waste Oil Boiler	0.6667	1.0000	0.9000	1.0000	0.3330	0.3670	0.5000	0.5000	1.0000	3.0000
	Waterfall Desludging Units	1.0000	0.2500	0.9000	1.0000	0.1000	0.4670	1.0000	1.0000	1.0000	4.0000
	Off Base Jet Noise Abatement	0.3333	0.2500	0.9000	1.0000	0.7000	1.0000	0.5000	0.5000	1.0000	5.0000

Appendix M (continued): Revised Data, First Iteration

	Project Title	Total Cost Points	Payback Period Points	Obligation Rate	Ready to Execute	Local	National	Safety Risk	Health Risk	Environmental Contribution	Base Priority
previous column's total (D)		8.6667	7.5000	14.2857	15.0000	8.8600	10.0340	9.3000	10.3000	13.5000	45.0000
(d)/(D)	Repellents/Reuse Spent Plastic Media Beads	0.0769	0.1333	0.0670	0.0667	0.0564	0.0232	0.0108	0.0097	0.0370	0.0222
	Aircraft Corrosion Control Recycle Equipment	0.0385	0.0333	0.0670	0.0667	0.0677	0.0166	0.0108	0.0097	0.0370	0.0444
	Supercritical Fluid Cleaning	0.0385	0.0333	0.0670	0.0667	0.0866	0.0797	0.0538	0.0485	0.0741	0.0667
	Waste Recycle Equipment	0.0769	0.1333	0.0670	0.0667	0.0339	0.0199	0.0108	0.0097	0.0370	0.0889
	Photopyrolysis Depaint System	0.0385	0.0667	0.0670	0.0667	0.0979	0.0366	0.1075	0.0971	0.0741	0.1111
	Baseline Pollution Prevention Audits	0.0385	0.1000	0.0700	0.0667	0.0602	0.0830	0.0538	0.0485	0.0741	0.0222
	Freon Recovery Recycling and Storage Equipment	0.0769	0.0333	0.0700	0.0667	0.0714	0.0997	0.0538	0.0971	0.0741	0.0444
	Replace Refrigeration Purge Units	0.0769	0.0333	0.0700	0.0667	0.0714	0.0997	0.0538	0.0971	0.0741	0.0667
	Needleless Intravenous System	0.1154	0.0333	0.0700	0.0667	0.0621	0.0830	0.1075	0.0971	0.0741	0.0889
	Electronic Imaging System	0.0385	0.0667	0.0700	0.0667	0.0577	0.0764	0.1075	0.0971	0.0741	0.1111
	Phaseout of Ozone Depleting Chemicals	0.0385	0.0333	0.0630	0.0667	0.1129	0.0997	0.1075	0.0971	0.0741	0.0222
	Pollution Prevention Assessment Opportunity	0.1154	0.1000	0.0630	0.0667	0.0940	0.0997	0.1075	0.0971	0.0741	0.0444
	Waste Oil Boiler	0.0769	0.1333	0.0630	0.0667	0.0376	0.0366	0.0538	0.0485	0.0741	0.0667
	Waterfall Desludging Units	0.1154	0.0333	0.0630	0.0667	0.0113	0.0465	0.1075	0.0971	0.0741	0.0889
	Off Base Jet Noise Abatement	0.0385	0.0333	0.0630	0.0667	0.0790	0.0997	0.0538	0.0485	0.0741	0.1111

Appendix M (continued): Revised Data, First Iteration

	Project Title	Total Cost Points	Payback Period Points	Obligation Rate	Ready to Execute	Local	National	Safety Risk	Health Risk	Environmental Contribution	Base Priority
check previous column's math		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
(d/D)*(natural log(d/D))	Repelletize/Reuse Spent Plastic Media Beads	-0.1973	-0.2687	-0.1811	-0.1805	-0.1622	-0.0874	-0.0487	-0.0450	-0.1221	-0.0846
	Aircraft Corrosion Control Recycle Equipment	-0.1253	-0.1134	-0.1811	-0.1805	-0.1823	-0.0682	-0.0487	-0.0450	-0.1221	-0.1384
	Supercritical Fluid Cleaning	-0.1253	-0.1134	-0.1811	-0.1805	-0.2118	-0.2016	-0.1572	-0.1469	-0.1928	-0.1805
	Waste Recycle Equipment	-0.1973	-0.2687	-0.1811	-0.1805	-0.1146	-0.0780	-0.0487	-0.0450	-0.1221	-0.2151
	Photopyrolysis Depaint System	-0.1253	-0.1805	-0.1811	-0.1805	-0.2274	-0.1210	-0.2398	-0.2264	-0.1928	-0.2441
	Baseline Pollution Prevention Audits	-0.1253	-0.2303	-0.1861	-0.1805	-0.1691	-0.2066	-0.1572	-0.1469	-0.1928	-0.0846
	Freon Recovery Recycling and Storage Equipment	-0.1973	-0.1134	-0.1861	-0.1805	-0.1885	-0.2298	-0.1572	-0.2264	-0.1928	-0.1384
	Replace Refrigeration Purge Units	-0.1973	-0.1134	-0.1861	-0.1805	-0.1885	-0.2298	-0.1572	-0.2264	-0.1928	-0.1805
	Needleless Intravenous System	-0.2492	-0.1134	-0.1861	-0.1805	-0.1725	-0.2066	-0.2398	-0.2264	-0.1928	-0.2151
	Electronic Imaging System	-0.1253	-0.1805	-0.1861	-0.1805	-0.1645	-0.1965	-0.2398	-0.2264	-0.1928	-0.2441
	Phaseout of Ozone Depleting Chemicals	-0.1253	-0.1134	-0.1742	-0.1805	-0.2462	-0.2298	-0.2398	-0.2264	-0.1928	-0.0846
	Pollution Prevention Assessment Opportunity	-0.2492	-0.2303	-0.1742	-0.1805	-0.2223	-0.2298	-0.2398	-0.2264	-0.1928	-0.1384
	Waste Oil Boiler	-0.1973	-0.2687	-0.1742	-0.1805	-0.1233	-0.1210	-0.1572	-0.1469	-0.1928	-0.1805
	Waterfall Desludging Units	-0.2492	-0.1134	-0.1742	-0.1805	-0.0506	-0.1428	-0.2398	-0.2264	-0.1928	-0.2151
	Off-Base Jet Noise Abatement	-0.1253	-0.1134	-0.1742	-0.1805	-0.2005	-0.2298	-0.1572	-0.1469	-0.1928	-0.2441

Appendix M (continued): Revised Data, First Iteration

	Total Cost Points	Payback Period Points	Obligation Rate	Ready to Execute	Local	National	Safety Risk	Health Risk	Environmental Contribution	Base Priority
previous column's sums	-2.6112	-2.5345	-2.7071	-2.7081	-2.6247	-2.5788	-2.5279	-2.5338	-2.6797	-2.5884
e(d) = sum*(-1)/ln(m)	0.9642	0.9359	0.9997	1.0000	0.9692	0.9523	0.9335	0.9357	0.9895	0.9558
Big E = sum(e(d))	9.6358									
lambda bar = 1/(n-E)*(1-e(d))	0.0982	0.1759	0.0009	0.0000	0.0845	0.1310	0.1827	0.1767	0.0287	0.1213

Appendix M (continued): Revised Data, First Iteration

	Project Title	Total Cost Points	Payback Period Points	Obligation Rate	Ready to Execute	Local	National	Safety Risk	Health Risk	Environmental Contribution	Base Priority
lambda bar * (w)		0.0079	0.0281	0.0000	0.0000	0.0169	0.0262	0.0055	0.0053	0.0009	0.0133
sum of lambda bar*(w)	0.1041										
lambda bar*(w) / sum of lambda bar*(w)	=lambda-sub-i	0.0754	0.2703	0.0004	0.0000	0.1624	0.2516	0.0526	0.0509	0.0083	0.1282
deviation table (1-d)	Repelletize/Reuse Spent Plastic Media Beads	0.3333	0.0000	0.0429	0.0000	0.5000	0.7670	0.9000	0.9000	0.5000	0.0000
	Aircraft Corrosion Control Recycle Equipment	0.6667	0.7500	0.0429	0.0000	0.4000	0.8330	0.9000	0.9000	0.5000	-1.0000
	Supercritical Fluid Cleaning	0.6667	0.7500	0.0429	0.0000	0.2330	0.2000	0.5000	0.5000	0.0000	-2.0000
	Waste Recycle Equipment	0.3333	0.0000	0.0429	0.0000	0.7000	0.8000	0.9000	0.9000	0.5000	-3.0000
	Photopyrolysis Depaint System	0.6667	0.5000	0.0429	0.0000	0.1330	0.6330	0.0000	0.0000	0.0000	-4.0000
	Baseline Pollution Prevention Audits	0.6667	0.2500	0.0000	0.0000	0.4670	0.1670	0.5000	0.5000	0.0000	0.0000
	Freon Recovery Recycling and Storage Equipment	0.3333	0.7500	0.0000	0.0000	0.3670	0.0000	0.5000	0.0000	0.0000	-1.0000
	Replace Refrigeration Purge Units	0.3333	0.7500	0.0000	0.0000	0.3670	0.0000	0.5000	0.0000	0.0000	-2.0000
	Needleless Intravenous System	0.0000	0.7500	0.0000	0.0000	0.4500	0.1670	0.0000	0.0000	0.0000	-3.0000
	Electronic Imaging System	0.6667	0.5000	0.0000	0.0000	0.4890	0.2330	0.0000	0.0000	0.0000	-4.0000
	Phaseout of Ozone Depleting Chemicals	0.6667	0.7500	0.1000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Pollution Prevention Assessment Opportunity	0.0000	0.2500	0.1000	0.0000	0.1670	0.0000	0.0000	0.0000	0.0000	-1.0000
	Waste Oil Boiler	0.3333	0.0000	0.1000	0.0000	0.6670	0.6330	0.5000	0.5000	0.0000	-2.0000
	Waterfall Desludging Units	0.0000	0.7500	0.1000	0.0000	0.9000	0.5330	0.0000	0.0000	0.0000	-3.0000
	Off-Base Jet Noise Abatement	0.6667	0.7500	0.1000	0.0000	0.3000	0.0000	0.5000	0.5000	0.0000	-4.0000

Appendix M (continued): Revised Data, First Iteration

	Project Title	Total Cost Points	Payback Period Points	Obligation Rate	Ready to Execute	Local	National	Safety Risk	Health Risk	Environmental Contribution	Base Priority
abs value of lambda-sub-i*(1-d)	Repelletize/Reuse Spent Plastic Media Beads	0.0251	0.0000	0.0000	0.0000	0.0812	0.1930	0.0474	0.0458	0.0041	0.0000
	Aircraft Corrosion Control Recycle Equipment	0.0503	0.2027	0.0000	0.0000	0.0650	0.2096	0.0474	0.0458	0.0041	0.1282
	Supercritical Fluid Cleaning	0.0503	0.2027	0.0000	0.0000	0.0378	0.0503	0.0263	0.0254	0.0000	0.2564
	Waste Recycle Equipment	0.0251	0.0000	0.0000	0.0000	0.1137	0.2013	0.0474	0.0458	0.0041	0.3845
	Photopyrolysis Depaint System	0.0503	0.1351	0.0000	0.0000	0.0216	0.1593	0.0000	0.0000	0.0000	0.5127
	Baseline Pollution Prevention Audits	0.0503	0.0676	0.0000	0.0000	0.0758	0.0420	0.0263	0.0254	0.0000	0.0000
	Freon Recovery Recycling and Storage Equipment	0.0251	0.2027	0.0000	0.0000	0.0596	0.0000	0.0263	0.0000	0.0000	0.1282
	Replace Refrigeration Purge Units	0.0251	0.2027	0.0000	0.0000	0.0596	0.0000	0.0263	0.0000	0.0000	0.2564
	Needleless Intravenous System	0.0000	0.2027	0.0000	0.0000	0.0731	0.0420	0.0000	0.0000	0.0000	0.3845
	Electronic Imaging System	0.0503	0.1351	0.0000	0.0000	0.0794	0.0586	0.0000	0.0000	0.0000	0.5127
	Phaseout of Ozone Depleting Chemicals	0.0503	0.2027	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Pollution Prevention Assessment Opportunity	0.0000	0.0676	0.0000	0.0000	0.0271	0.0000	0.0000	0.0000	0.0000	0.1282
	Waste Oil Boiler	0.0251	0.0000	0.0000	0.0000	0.1083	0.1593	0.0263	0.0254	0.0000	0.2564
	Waterfall Desludging Units	0.0000	0.2027	0.0000	0.0000	0.1461	0.1341	0.0000	0.0000	0.0000	0.3845
	Off-Base Jet Noise Abatement	0.0503	0.2027	0.0000	0.0000	0.0487	0.0000	0.0263	0.0254	0.0000	0.5127

FINAL SCORES (DISTANCES)

Project Number	Project Title	Score/Distance
SM-931602	Repelletize/Reuse Spent Plastic Media Beads	0.3966
SM-921602	Aircraft Corrosion Control Recycle Equipment	0.7530
SM-981604	Supercritical Fluid Cleaning	0.6493
SM-921643	Waste Recycle Equipment	0.8219
SM-921610	Photopyrolysis Depaint System	0.8790
WP-xxxxxx	Baseline Pollution Prevention Audits	0.2875
WP-xxxxxx	Freon Recovery Recycling and Storage Equipment	0.4419
WP-xxxxxx	Replace Refrigeration Purge Units	0.5701
WP-xxxxxx	Needleless Intravenous System	0.7023
WP-xxxxxx	Electronic Imaging System	0.8362
OO-940727	Phaseout of Ozone Depleting Chemicals	0.2530
OO-920797	Pollution Prevention Assessment Opportunity	0.2229
OO-870172	Waste Oil Boiler	0.6008
OO-920743	Waterfall Desludging Units	0.8675
OO-960732	Off-Base Jet Noise Abatement	0.8662

PRIORITIZED LIST OF PROJECTS

Project Number	Project Title	Score/Distance
OO-920797	Pollution Prevention Assessment Opportunity	0.2229
OO-940727	Phaseout of Ozone Depleting Chemicals	0.2530
WP-xxxxxx	Baseline Pollution Prevention Audits	0.2875
SM-931602	Repelletize/Reuse Spent Plastic Media Beads	0.3966
WP-xxxxxx	Freon Recovery Recycling and Storage Equipment	0.4419
WP-xxxxxx	Replace Refrigeration Purge Units	0.5701
OO-870172	Waste Oil Boiler	0.6008
SM-981604	Supercritical Fluid Cleaning	0.6493
WP-xxxxxx	Needleless Intravenous System	0.7023
SM-921602	Aircraft Corrosion Control Recycle Equipment	0.7530
SM-921643	Waste Recycle Equipment	0.8219
WP-xxxxxx	Electronic Imaging System	0.8362
OO-960732	Off-Base Jet Noise Abatement	0.8662
OO-920743	Waterfall Desludging Units	0.8675
SM-921610	Photopyrolysis Depaint System	0.8790

Appendix N: Revised Data, Second Iteration

SECOND ITERATION

Revised Attribute Weights:

	FINANCIAL CONSIDERATIONS				POLITICAL CONSIDERATIONS		OTHER				
	Total Cost	Payback Period	Obligation Rate	Ready to Execute	Local	National	Safety Risk	Health Risk	Environmental Contribution	Base Priority	Total Points
Points	8.0000	50.0000	4.0000	12.0000	20.0000	20.0000	3.0000	3.0000	3.0000	11.0000	134
Overall Weight (w)	0.0597	0.3731	0.0299	0.0896	0.1493	0.1493	0.0224	0.0224	0.0224	0.0821	
Check sum	1.0000										

Revised Prioritized List of Projects:

Project Number	Project Title	Score/Distance
OO-920797	Pollution Prevention Assessment Opportunity	0.2328
SM-931602	Repelletize/Reuse Spent Plastic Media Beads	0.2519
WP-xxxxxx	Baseline Pollution Prevention Audits	0.2738
OO-870172	Waste Oil Boiler	0.3816
OO-940727	Phaseout of Ozone Depleting Chemicals	0.4343
SM-921643	Waste Recycle Equipment	0.5221
WP-xxxxxx	Freon Recovery Recycling and Storage Equipment	0.5543
WP-xxxxxx	Replace Refrigeration Purge Units	0.6357
SM-981604	Supercritical Fluid Cleaning	0.6860
WP-xxxxxx	Electronic Imaging System	0.7135
WP-xxxxxx	Needleless Intravenous System	0.7197
SM-921610	Photopyrolysis Depaint System	0.7407
SM-921602	Aircraft Corrosion Control Recycle Equipment	0.7519
OO-960732	Off-Base Jet Noise Abatement	0.8238
OO-920743	Waterfall Desludging Units	0.8246

Appendix O: Revised Data, Third Iteration

THIRD ITERATION

Revised Attribute Weights:

	FINANCIAL CONSIDERATIONS				POLITICAL CONSIDERATIONS		OTHER				
	Total Cost	Payback Period	Obligation Rate	Ready to Execute	Local	National	Safety Risk	Health Risk	Environmental Contribution	Base Priority	Total Points
Points	8.0000	25.0000	4.0000	12.0000	50.0000	50.0000	3.0000	3.0000	3.0000	11.0000	169
Overall Weight (w)	0.0473	0.1479	0.0237	0.0710	0.2959	0.2959	0.0178	0.0178	0.0178	0.0651	
Check sum	1.0000										

Revised Prioritized List of Projects:

Project Number	Project Title	Score/Distance
OO-920797	Pollution Prevention Assessment Opportunity	0.1701
OO-940727	Phaseout of Ozone Depleting Chemicals	0.2070
WP-xxxxxx	Baseline Pollution Prevention Audits	0.2833
WP-xxxxxx	Freon Recovery Recycling and Storage Equipment	0.3640
WP-xxxxxx	Replace Refrigeration Purge Units	0.4363
SM-931602	Repelletize/Reuse Spent Plastic Media Beads	0.4556
SM-981604	Supercritical Fluid Cleaning	0.5051
WP-xxxxxx	Needleless Intravenous System	0.5578
OO-870172	Waste Oil Boiler	0.5653
OO-960732	Off-Base Jet Noise Abatement	0.5941
WP-xxxxxx	Electronic Imaging System	0.6313
SM-921610	Photopyrolysis Depaint System	0.6917
SM-921602	Aircraft Corrosion Control Recycle Equipment	0.7213
SM-921643	Waste Recycle Equipment	0.7300
OO-920743	Waterfall Desludging Units	0.7907

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Vita

Scott W. McPherson is originally from Seattle, Washington where he was born in 1961. He completed a Bachelor of Science in Industrial Engineering at Oregon State University in 1985, and was commissioned into the Air Force the same year. He served in the Manpower Management career field until 1988 with Detachment 9, 4400th Management Engineering Squadron at Luke AFB, Arizona. During that assignment, he acted as Technician, Branch Chief, and Commander. Following that duty, he was assigned to the 351st Civil Engineering Squadron (CES), Whiteman AFB, Missouri, as the Industrial Engineer. In that capacity, he was responsible for the allocation of manpower and computer resources supporting the B-2 beddown program. Shortly thereafter, he took over as Chief of the Heavy Repair Section where he oversaw construction and major renovation activities. Following this assignment, he began work in the field of environmental engineering. From 1989 to 1990, he worked as the Base Environmental Coordinator while assigned to the 51st CES, Osan AB, South Korea. During his tour in Korea, Capt McPherson was selected for the Air Force Institute of Technology as part of the inaugural Engineering and Environmental Management master of science program. In the process of completing his studies, force drawdowns presented Capt McPherson with the opportunity to leave the service and return to the Pacific Northwest with his wife, Nora, and newborn son, Kyle.

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Vita

Captain Debra J. Watts was born on 24 August 1953 in Middlesex, England (her father was serving in the Air Force in Ruislip, England). She graduated from Princeton High School in Princeton, West Virginia in 1971. She later enlisted in the Air Force in 1977. In 1981, she was selected to attend Arizona State University in Tempe, Arizona via the Airman's Education Commissioning Program, where she graduated with a Bachelor of Science degree in Industrial Engineering. Her first assignment as a commissioned officer was with Air Force Systems Command at Patrick AFB, Florida, where she served as Chief of the Industrial Engineering Branch in the 6550th Civil Engineering Squadron (CES). Eighteen months later, she was reassigned to Sembach AB, Germany, where she again served as Chief of the Industrial Engineering Branch for the 66th CES. In 1985, she was selected as a resource manager for Headquarters, United States Air Forces in Europe, Directorate of Civil Engineering and Services. In this capacity, she was responsible for the allocation of Civil Engineering forces in Europe. She also served as the 16th Air Force Programmer. She attended Squadron Officer School in 1988 and proceeded from there to Hill AFB, Utah where she was Chief of Readiness for the 2849th CES. She was later selected as Commander for the 2849th Services Squadron, where she served until entering the School of Civil Engineering and Services, Air Force Institute of Technology, in 1991.

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13. ABSTRACT *(Maximum 200 words)*

This research developed a model to prioritize pollution prevention projects for the distribution of limited financial resources. This model was designed for use at the major command (MAJCOM) level. Each MAJCOM is allowed to select the attributes believed to be most appropriate for evaluating pollution prevention projects. The system also allows the flexibility for MAJCOMs to weight the attributes in accordance with requirements. The model uses "fuzzy logic" and the Displaced Ideal Model (DIM) to prioritize projects which currently do not have an imminent compliance deadline, but are important due to potential noncompliance with future regulations. These projects are also important because their completion demonstrates a commitment to good management practices which make better use of resources and otherwise enhance the environment. The model uses the "amount of information" given by the data to integrate and compare qualitative and quantitative criteria. The prioritization includes considering factors such as total project cost, health and safety considerations, and political sensitivity. The model can also be used to prioritize projects that are currently out of compliance (Level I) or projects which must meet an established deadline before it lapses into noncompliance (Level II).

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165

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
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